ATOMIC STRUCTURE

MATHEMATICAL EQUATIONS

(1) The expression of e/m value of the electron in term of velocity of electron, radius of curvature of electron 'r' and the strength of magnetic field "H" applied and electrical field strenth 'V' is

$$\frac{e}{m} = \frac{V}{rH}$$

(2) The expression to determine the charge of electron by oil drop experiment is

$$\frac{u}{v} = \frac{mg}{Ee - mg}$$

where

u = downward velocity of the droplet
v = upward velocity of the droplet
m = mass of the droplet g = acceleration due to gravity
e = charge of electron E = strength of electrical field

(3) The energy is related to frequency, wavelength and wave number of the photon by the following equations

$$E = h\upsilon \quad , \quad E = \frac{hc}{\lambda} \quad , \quad E = hc\bar{\upsilon}$$

(4) According to fourth postulate of Bohr's model, the angular momentum of the moving electron is integral multiple of $\frac{h}{2\pi}$.

$$mvr = \frac{nh}{2\pi}$$

(5) The formula derived by Bohr for the radius of orbit of an atom having one electron around the nucleus is

$$r = \frac{h^2 \epsilon_0}{\pi m e^2}\left(\frac{n^2}{Z}\right)$$

where

h = Planck's constant, n = number of orbit,
ϵ_0 = permitivity constant of medium,
Z = number of the proton in nucleus, e = charge of electron

(6) When the values of constants are substituted in above equation then

$$r = 0.529\left(\frac{n^2}{Z}\right) A^\circ$$

So, greater the number of orbit greater the radius. Greater the number of protons in the nucleus smaller the radius.

(7) The formula for the energy of electron moving around the nucleus of atom having one electron is

$$E_n = \frac{-e^4 m}{8 \in_0^2 h^2} \left(\frac{Z^2}{n^2}\right)$$

(8) When we put the values of the constants in above equation; then the equation is simplified as follows

$$E_n = -2.18 \times 10^{-18} \left(\frac{Z^2}{n^2}\right) J.$$

(9) When the expression for the energy is multiplied by Avogadro's number and divided by 1000, we get the expression for the energy of electron for one mole of H-atoms

$$E_n = \frac{-1313.315}{n^2} \text{ kJ mole}^{-1}.$$

(10) The formula for the energy difference of any two orbits of H-atom is

$$\Delta E = 2.18 \times 10^{-18} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] J.$$

(11) The formula of frequency of photon emitted or absorbed when the electron jumps between any two orbits is

$$\upsilon = 3.2906 \times 10^{+15} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] Hz.$$

(12) Formula for the wave number of photon which is emitted or absorbed when the electron jumps between any two orbits is

$$\bar{\upsilon} = 1.09678 \times 10^{+7} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] m^{-1}$$

(13) The relationship between the frequency of the x-rays, atomic number of the metal and screening constant of the electron given by Moseley is

$$\sqrt{\upsilon} = a(z - b).$$

(14) The relationship between wavelength and the momentum of electron given by de-Broglie is

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

(15) Mathematical expression for the Heisenberg's uncertainty principle is

$$\Delta X \times \Delta P \approx \frac{h}{2\pi}$$

'ΔX' is uncertainty in position of electron.
'ΔP' is uncertainty in momentum of electron.

DEFINITIONS

(May be used in short questions with examples)

(1) Atomic absorption spectra: **(Lahore 2009, Bahawalpur 2009)**

That spectrum which is produced from the radiation from which the rays of some particular wavelength have been absorbed by the substances. When the substance is consisted of atoms, then it is called atomic absorption spectrum. The atomic absorption spectra of H_2 is given by Lyman, Balmer, Paschen etc. series on the photographic plate in the form of lines.

(2) Anode rays:

It is a stream of positively charged particles which travel from anode towards the cathode at high voltage and low pressure of the gas in the discharge tube. These rays are also called positive rays or canal rays. They can pass through holes of anode. For H_2 gas anode rays are protons.

(3) Atomic model:

It is a set of assumptions which can be used to explain the inter-related experimental observations and properties of an atom in terms of familiar systems. The correctness of the model is inferred from experimental facts. Bohr gave the atomic model of H or H-like species.

(4) Atomic spectrum: **(Lahore 2009)**

That spectrum which is produced from the light emitted by the burning of an element. This spectrum is due to jumping of outer most electrons from lower to higher levels and their coming back.

(5) Auf-bau principle: **(Bahawalpur 2008)**

According to this principle, the electrons are placed in energy sub-levels in the order of increasing energy values. The electron is first placed in 1s orbital, then 2s orbital, then 2p and so on. Auf-bau is German term which means "building up".

(6) Azimuthal quantum number:

It gives the information about the shape of the orbital. It is also called angular momentum quantum number. When $l = 0$, it represents s orbital, when $l = 1$ p-orbital, when $l = 2$, d-orbital and when $l = 3$, it is f-orbital.

(7) Bohr's atomic model:

Simplest atomic model of atom is based upon the quantum theory of radiation and laws of the classical mechanics. This model does not accommodate Heisenberg's uncertainty principle and idea of the standing wave of electron. But it gives best description of H and H-likes species.

(8) Cathode rays:

It is a stream of negatively charged particles which are called electrons. These are produced in a discharge tube at very high voltage and at a very low pressure, and move from cathode towards the anode. They are produced by every substance in the gaseous state.

(9) Continuous spectrum: **(Sargodha 2008, Multan 2009, B.Pur 2009)**

That spectrum in which different colours of the visible region or different wavelengths of visible or invisible region are diffused into each other. The whole of the photographic plate is white and there are no dark spaces in the spectrum. The spectrum of sun is continuous

(10) de-Borglie's dual nature of matter:

Just like the dual nature of light, de-Broglie said that the wavelength of microscopic particles are inversely proportional to the momentum of a particle. In $\lambda = \frac{h}{mv}$, λ is wavelength of wave of particle, m is its mass and v is its velocity.

(11) Electron:

A negatively charged particle which is 1836 times lighter than proton having mass 9.1×10^{-31} kg and charge equal to that of proton *i.e.*, 1.602×10^{-19} C.

(12) Emission spectrum: **(Lahore 2009, Multan 2009, B.Pur 2009)**

It is that spectrum which is produced from the radiations emitted by the substance. The electrons which are promoted to higher energy levels fall back to original levels. This spectrum produces bright lines on the dark background.

(13) Frequency:

It is the number of waves produced by light or a microscopic particle in one second. Its units are cycles s^{-1} or s^{-1} or Hz. The frequency range of visible region is 7.88×10^{14} to 3.94×10^{14} Hz.

(14) Heisenberg's uncertainty principle: **(Guj. 2009, B.Pur 2009)**

According to this principle it is difficult to determine the position as well as the momentum of the electron simultaneously. $\Delta m \times \Delta p \approx \frac{h}{2\pi}$.

(15) Hund's rule:

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. For $_7N = 1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$

(16) Invisible spectrum:

That part of the spectrum which cannot be seen through the naked eye. The invisible regions of the spectrum of greater wavelength than the visible include I.R, microwave and radio frequency region. The other parts of invisible spectrum have wavelengths shorter than visible and include U.V, x-rays, γ-rays and cosmic rays.

(17) Isobars:

Isobars are the atoms of the different elements having the same mass number but different atomic numbers. They have different number of protons and electrons in them. $_{18}Ar^{40}$ is the isobar of $_{19}K^{40}$.

(18) Isoelectronic species:

Those species which have the same number of electrons and different charges on their nucleus *e.g.*, $Na^{\oplus}$, $Mg^{(2+)}$ and Ne° have ten electrons each but the number of protons are different.

(19) Isotopes:

Atoms of the same elements having same atomic number, but different mass number are called isotopes. They differ in number of neutrons in them, but they have the same protons and electrons. Neon has three isotopes i.e., $^{20}_{10}Ne$, $^{21}_{10}Ne$ and $^{22}_{10}Ne$.

(20) Line spectrum: **(Sargodha 2008, B.Pur 2009, Multan 2009)**

That spectrum in which the bands of the colour are separated by dark spaces. It is of two types *i.e.*, line emission and line absorption spectra. These lines are produced due to emission of photons of particular wave number during jumping of electrons.

(21) Magnetic quantum number:

That quantum number which gives us the information about the orientation of orbital in space. When m = 0 it is s-orbital for m = 1, 0, –1 there are p_x, p_y and p_z orbitals.

(22) Neutron:

Neutral particle present in nucleus of the atom having mass very close to that of proton and is equal to 1.675×10^{-27} kg.

(23) (n + l) rule:

This is the sum of principal and azimuthal quantum number. According to this rule, the electrons are filled in energy subshells in the increasing order of (n + l) values. When two or more than two subshells have the same (n + l) value, then that one is placed first whose 'n' value is smaller.

(24) Orbit: **(R. Pindi 2012)**

The fixed path around the nucleus of the atom, where the electron moves is called the orbit of electron. It is imaginary path and we suppose it for the sake of convience.

(25) Orbital: **(Sargodha 2008, R. Pindi 2012)**

It is the space around the nucleus where the probability for finding the electron is maximum. This is due to wavy nature of electron.

(26) Pauli's Exclusion Principle: **(Lahore 2011)**

It can be stated in two ways:

(i) The two electrons in the same orbital should have opposite spins.

(ii) No two electrons in an atom can have all the four quantum numbers same.

(27) Permitivity of vacuum:

It is the proportionality constant when we measure the force of attraction of the nucleus and the electrons. Its value is $8.84 \times 10^{-12}\ C^2J^{-1}m^{-1}$ and is represented by $\in^o$.

(28) Planck's constant (h):

It is the ratio between energy of the photon and the frequency of that photon. Its value is 6.625×10^{-34} Js. The energy is expressed in Joules and frequency in sec^{-1}. It is also expressed as 6.625×10^{-27} ergs sec. This is true when the energy is measured in ergs and frequency in sec^{-1}.

(29) Principal quantum number:

It gives the information about the distance of electron from the nucleus and the energy of electrons. Its values are positive integers and never zero.

(30) Proton:

It is a positively charged particle with mass 1.6726×10^{-27} kg and having a charge of 1.602×10^{-19} C. It resides in the nucleus of an atom. H-atom has only one proton in the nucleus.

(31) Quantum numbers:

The sets of numerical values which satisfy the Schrodinger wave equation, when it is solved for H-atom. There are four quantum numbers i.e., n, l, m and s.

(32) Rutherford's atomic model:

It is earliest model given by a scientist about the structure of matter. It is based upon the laws of motion and gravitation. The nucleus of the atom lies in the center and electrons revolve around it in shells.

(33) Spectrometer:

That instrument which is used for the study of spectra by measuring the intensity and frequency of emitted or absorbed radiations.

(34) Spin quantum number:

This quantum number gives us the information about the spin of electron, whether clockwise or anti-clockwise. Spin means rotating around its own axis. Spin motion creates magnetic field and is represented by 1 or ↓.

(35) **Visible spectrum:**

That part of the spectrum which can be seen through the naked eye. It ranges from 400 nm to 750 nm. Its energy is less than U.V but more than I.R.

(36) **Wave number:** **(D.G. Khan 2013)**

It is number of waves produced by photon of light or a microscopic particle per unit length. It is expressed in cm^{-1} or m^{-1}. It is reciprocal of wavelength. $\bar{\nu} = \frac{1}{\lambda}$

(37) **Wavelength:** **(Lahore 2011, D.G. Khan 2013)**

It is the distance between two adjacent crests or troughs in a wave. It is expressed in nm, pm, A°. Greater the wavelength of a photon, smaller the frequency and energy associated with it.

MULTIPLE CHOICE QUESTIONS (EXERCISE OF THE TEXTBOOK)

MULTIPLE CHOICE QUESTIONS	ANSWER WITH REASONS
(1) The nature of positive rays depends on: (a) the nature of electrode (b) the nature of discharge tube (c) the nature of residual gas (d) all of the above	1. (c) **(Rwp. 2007, B.P. 2008, Lahore 2012, Lahore 2013, Guj. 2014)** When high speed cathode rays strike the atoms or molecules of gas enclosed in a discharge tube, they knock out electrons from the gas molecules. The rest of the portion of the atom or molecule is consisted of positive ion. Thus, the nature of the positive rays depends upon the nature of the residual gas.
(2) The velocity of photon is: (a) independent of its wavelength (b) depends on its wavelength (c) equal to square of its amplitude (d) depends on its source	2. (a) Light is consisted of many types of photons and the photons of all the wavelength have the same velocity. These photons may be of any region of spectrum.
(3) The wave number of the light emitted by a certain source is 2×10^6 m. The wavelength of this light is: (a) 500 nm (b) 500 m (c) 200 nm (d) 5×10^7 m	3. (a) **(Rwp. 2011, F. Abad 2014, Multan 2014, B. Pur 2014)** The value of the wave number $\bar{\nu} = 2 \times 10^6\ m^{-1}$ Since $\bar{\nu} = \frac{1}{\lambda}$ So, $\lambda = \frac{1}{\bar{\nu}}$ $\lambda = \frac{1}{2 \times 10^6\ m^{-1}}$ $\lambda = 5 \times 10^{-7}$ m $\lambda = 500 \times 10^{-9}$ m as, 10^{-9} m = 1 nm Thus 500×10^{-9} m = 500 nm
(4) Rutherford's model of atom failed because: (a) the atom did not have a nucleus and electrons (b) it did not account for the attraction between protons and neutrons (c) it did not account for the stability of the atom	4. (c) Rutherford's model is based on the laws of motion and gravitation. According to this model, the outermost electrons could not be stationary. If they were, they would gradually be attracted by the nucleus, till they fall into it. But for stable atomic structure the electrons were supposed to

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ANSWERS TO THE SHORT QUESTIONS

Cathode Rays

Q.1 Which observations tell the presence of cathode rays in the discharge tube? (Faisalabad 2008)

-1 کونسے مشاہدات یہ بتاتے ہیں کہ ڈسچارج ٹیوب میں کیتھوڈ ریز موجود ہیں؟

Ans: Cathode rays produced in the discharge tube (ایسی ٹیوب جس میں برقی رو بہہ رہی ہو) fall upon the surface of the glass tube just opposite to the cathode surface giving fluorescence (فلوریٹری عمل، فلوریت). Fluorescence has different colours which depends upon the nature of the glass tube.

Q.2 Why the cathode rays are produced in the discharge tube by applying a high voltage?

-2 زیادہ وولٹیج لگانے سے ڈسچارج ٹیوب میں کیتھوڈ ریز کیوں بنتی ہیں؟

Ans: When the voltage of 5000 – 10000 volts is applied at the pressure of around 0.01 torr, then a glow (چمک) appears and cathode rays travel from cathode towards the anode in the discharge tube. High voltage is necessary (زیادہ وولٹیج ضروری ہے) to break the molecules of the gas into atoms and to remove the electrons from outermost orbitals.

Q.3 How various experiments conducted in the cathode ray tube show that cathode rays are material particles with the negative charge on them? (Lahore 2007, Gujranwala 2008, B.P. 2008, Fd. 2009, Multan 2009)

-3 مختلف تجربات کیسے بتاتے ہیں کہ کیتھوڈ ریز مادہ کے ذرّے ہیں اور ان پر منفی چارج ہے؟

Ans: Cathode rays rotate a pin wheel (ایک پن ویل کو گھما دیتی ہیں). The vans of the pin wheel get the momentum (معیارِ حرکت) from the particles of the cathode rays and get the movement. When these rays are passed through the electrical field (برقی میدان), they are deflected (مڑ جاتا) towards the positive plate.

Q.4 Why is it necessary to decrease the pressure in the discharge tube to get the cathode rays? (Faisalabad 2007, Sarg. 2010, Guj. 2012, Lahore 2012, Sarg. 2014)

-4 ڈسچارج ٹیوب میں ریز پیدا کرنے کے لئے پریشر کو کم کیوں کرنا پڑتا ہے؟

Ans. The pressure in discharged tube is decreased to allow the cathode rays and anode rays to move freely (آزادی سے حرکت) from one electrode to the other. In this way the possibility of collisions between rays and the gas molecules are minimized (کیتھوڈ ریز اور گیس کے ایٹمز کے آپس میں ٹکراؤ کم سے کم رہ جاتے ہیں).

Q.5 Whichever gas is used in the discharge tube, the nature of the cathode rays remains the same. Why? (Model Paper-2006-07, Lahore 2009, D.G. Khan 2011, D. G. Khan 2012, Guj. 2013, Guj. 2014)

-5 ڈسچارج ٹیوب میں جو نسی گیس بھی بھری جائے۔ کیتھوڈ ریز کی فطرت ایک ہی رہتی ہے کیوں؟

Ans. All the gases are consisted of atoms or molecules. They have electrons in outermost orbitals. These electrons are detached (الگ کرنا) by the high voltage and due to collisions (زیادہ وولٹیج اور تصادموں سے), these electrons become free. They are repelled by the cathode and attracted towards the anode. That is why, they are called cathode rays. They are always electrons and nothing else (وہ الیکٹرانز کے سوائے کچھ نہیں ہوتے).

Q.6 Why e/m value of the cathode rays is just equal to that of electron?
(Rawalpindi 2007, Faisalabad 2007, B.Pur 2009, Sarg. 2009, Guj. 2012, D. G. Khan 2012, Lahore 2013, Sahiwal 2014, Lahore 2014)

-6 کیتھوڈ ریز کی (e/m) کی قیمت الیکٹران کی (e/m) کے برابر کیوں ہے؟

Ans. Since cathode rays are electrons, so their e/m values are just equal to those of electrons.

Q.7 How the bending of the cathode rays in the electric and magnetic fields shows that they are negatively charged? (Lahore 2014, D.G. Khan 2014)

-7 کیتھوڈ ریز کا جھکاؤ کس طرح ہمیں بتاتا ہے کہ ان پر منفی چارج ہے؟

Ans. Cathode rays are deflected (مُڑ جانا) towards the positive plate when electric field is applied. It shows that cathode rays are negatively charged. When cathode rays are passed through the magnetic field (مقناطیسی میدان), they bend perpendicular to the joining line of two poles (دو پولز کو ملانے والی لائن کے عموداً جھک جاتی ہیں). This is due to the negative charge. Anyhow, positively charged particles will bend in opposite direction to that of electrons in the magnetic field.

Anode Rays

Q.8 Why the positive rays are also called canal rays? Give its reason.
(Multan 2007, Sarg. 2010, Guj. 2010, M. Pure 2012, Guj. 2012, Guj. 2013, D.G. Khan 2013, Sarg. 2014, D.G. Khan 2014, Sahiwal 2014)

-8 مثبت ریز کو ہم کینال ریز بھی کہتے ہیں؟ اس کی وجہ بتائیں۔

Ans: They are detected by allowing them to pass through the canals (سوراخ یا نہریں) of cathode. These canals are the holes in the cathode material.

Q.9 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.
(Rwp. 2008, Lahore 2010, Rwp 2011, Multan 2012, Rwp. 2014)

-9 مختلف قسم کی گیسز کی اینوڈ ریز مختلف ہیں لیکن کیتھوڈ ریز ایک طرح کی ہوتی ہیں؟ کیوں؟

Ans. The nature of particles of positive rays in a discharge tube depend upon the nature of the gas because the nucleus of every gas has its own number of protons and neutrons. Greater the number of protons and neutrons in the nucleus of an atom or nuclei of the molecule, smaller the e/m values.
In the case of cathode rays which are always electrons, e/m values remain the same.

Q.10 The e/m value of the positive rays obtained from the hydrogen gas is 1836 times less than that of cathode rays. Justify it.
(Lahore 2007, Faisalabad 2010, Guj. 2011, Multan 2012, Rwp. 2013)

-10 H_2 گیس سے ملی اینوڈ ریز کی کمیت کیتھوڈ ریز سے 1836 گنا زیادہ ہوتی ہے۔ صحیح ثابت کریں۔

Ans. When we use hydrogen gas in the discharge tube, the positive rays are consisted of single protons. In cathode rays each ion is consisted of electrons. The proton is 1836 times heavier than that of electron. So e/m value of proton is 1836 times smaller than that of electron.

Q.11 Why the anode rays depend upon the nature of the gas?
(Faisalabad Board 2004, D.G. Khan 2013, Multan 2014)

-11 اینوڈ ریز گیس کی فطرت پر انحصار کیوں کرتی ہیں؟

Ans: Anode rays are those particles which are consisted (مشتمل ہوتے ہیں) of rest of the atom or molecule (باقی ماندہ ایٹم یا مالیکیول) after the removal of one electron. The mass of every anode ray particle depends upon the nature of the gas, so the anode rays for all gaseous substances (گیس کی حالت میں چیزیں) are different.

Q.12 How the idea of the proton can be verified by taking H_2 gas in the discharge tube? (D.G. Khan 2013)

-12 ڈسچارج ٹیوب میں H_2 گیس لے کر پروٹان کی ذات کے بارے میں کیا ثبوت ملتا ہے؟

Ans: In the discharge tube the molecules of H_2 are broken up into hydrogen atoms. These hydrogen atoms are deprived of (محروم کر دیا جاتا) their electrons and the nucleus consisted of one proton acts as particle of anode ray. In this way, if we study the anode rays, they give the properties of the protons.

Neutron

Q.13 What particles are formed by the decay of free neutrons? (Rwp 2005, Faisalabad 2008, Rwp. 2008, Multan 2008, B.P. 2008, Sarg. 2009, Faisalabad 2013, Lahore 2014, Lahore 2014, F. Abad 2014, Lahore 2014)

-13 جب نیوٹران ٹوٹتا ہے تو کونسے ذرّات بنتے ہیں؟

Ans: A free neutron decays (کم تر چیزیں بناتے ہوئے تبدیل ہونا) into proton, electron and a neutrino.

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

neutron proton electron neutrino

The neutron has no charge and its mass is very close to that of proton.

Q.14 How the slow neutrons prove to be more effective than the fast neutrons? (Mirpure Board 2004, Multan 2008, B.P. 2008, Faisalabad 2013, Guj. 2014, Lahore 2014)

-14 سست چلتے ہوئے نیوٹرانز زیادہ تیز چلنے والوں کے مقابلہ میں بہتر طریقے سے اثر انداز ہوتے ہیں۔ کیسے؟

Ans: When the travelling neutrons (سفر کرتے نیوٹرانز) have energy below one electron volt then they are called slow neutrons. They are more effective in fission processes (توڑنے کے عمل کے لئے بڑے موثر ثابت ہوتے ہیں). Slow neutrons hit the copper metal and γ-radiations are emitted, giving us a new isotope of copper i.e., $^{66}_{29}Cu$, which is again radioactive.

$$^{65}_{29}Cu \longrightarrow {}^{66}_{29}Cu + h\nu \text{ (radiations)}$$

$$^{66}_{29}Cu \longrightarrow {}^{66}_{30}Zn + {}_{1}e^{0}$$

Rutherford's Model

Q.15 How did Rutherford's model of an atom first of all proved the existence of nucleus of the atom? (Guj. 2008)

-15 رودر فورڈ کے ایٹم کے ماڈل نے سب پہلے کیسے ثابت کیا کہ ایٹم میں نیوکلیس ہوتا ہے؟

Ans: Rutherford observed that most of the α-particles passed straight through (سیدھے گزر جاتے ہیں) the gold foil without any deflection (جھکاؤ) from the path. Few of them were deflected at some angle more than 90° and a few were deflected back (پیچھے مڑ جاتے ہیں) on the original path (اپنے پہلے راستے پر). He concluded (نتیجے پر پہنچنا) that the

atom contains heavy and positively charged part at the center. This heavy part at the center is called nucleus.

Q.16 What are the defects of Rutherford's atomic model?

(Multan 2007, 2008, Rwp. 2009, Multan 2009, Fd. 2009, Sarg. 2010, Rwp. 2010, Lahore 2011, Rwp. 2011, Multan 2011, Guj. 2013, Faisalabad 2013, Rwp. 2013, D.G. Khan 2014, Rwp. 2014)

-16 ردر فورڈ کے ایٹم کے ماڈل میں کیا نقائص ہیں؟

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

(ii) The revolving electron (گھومتا الیکٹران) should emit the energy continuously (تواتر کے ساتھ) and by producing a spiral path (چکر دار راستہ), it should ultimately (آخر کار) fall into the nucleus. But actually (حقیقتاً) the atoms don't do it.

(iii) The atom should give continuously spectra (تسلسل والا سپکٹرا), but they give the line spectra (لائنز پر مشتمل سپکٹرا).

Planck's Quantum Theory

Q.17 How the energy of the photon can be calculated from the measurement of the frequency, wavelength or wave number of the photon?

(Gujranwala-2006, Bahawalpur-2008, Guj. 2011, D.G. Khan 2014)

-17 ایک فوٹان کی انرجی آپ اس کی تعدد، لہری لمبائی اور ویو نمبر سے کیسے نکال سکتے ہیں؟

Ans: According to Planck's theory, the energy depends upon the frequency (تعدد) wavelength (لہر کی لمبائی) and wave number (ویو نمبر) of photon as in the equations

$$E = h\upsilon \quad , \quad E = \frac{hc}{\lambda} \quad . \quad \text{Since } \bar{\upsilon} = \frac{1}{\lambda} \quad , \quad E = hc\bar{\upsilon}$$

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

Q.18 How does Bohr introduce the Planck's quantum theory in his model? Give its two postulates. **(Guj. 2014, Multan 2014)**

-18 بوہر نے اپنے ایٹم کے ماڈل میں پلانک کی کوانٹم تھیوری کو کیسے شامل کیا؟

Ans: Bohr proposed (مشورہ دیا) that electrons move around the nucleus in the fixed orbits with definite energies (خاص انرجی کے ساتھ). Whenever, they change the orbits they emit or absorb the energy in terms of photons which was suggested by Planck in 1900. (i) The electron revolves around the nucleus in circular way. (ii) The electron in same orbit keeps the energy constant.

Bohr's Atomic Model

Q.19 According to Bohr's model, the angular momentum of moving electron is a quantized. What do you mean by this?

-19 بوہر کے ماڈل کے مطابق چلتے ہوئے الیکٹران کا زاویائی معیارِ حرکت $\frac{h}{2\pi}$ کا سادے ہندسے کا حاصلِ ضرب ہے۔ اس کا کیا مطلب ہے؟

Ans: Bohr's said that the angular momentum (زاویائی معیارِ حرکت) 'mvr' of the moving electron is integral multiple (سادے ہندسے سے ضرب دینا) of $\frac{h}{2\pi}$

$$mvr = \frac{nh}{2\pi}$$

Where 'n' is simple multiple or integral multiple. It is basically (بنیادی طور پر) number of orbits so,

$$mvr = \frac{1\,h}{2\pi}, \frac{2\,h}{2\pi}, \frac{3\,h}{2\pi}, \ldots\ldots$$

It means that, there are quantum jumps in the angular momentum values.

(زاویائی معیارِ حرکت مستقل قیمتیں رکھتے ہیں۔ ان کے علاوہ اگر الیکٹران کسی اور قیمت کے زاویائی معیارِ حرکت کے ساتھ نیوکلیس کے گرد چکر لگانا چاہے گا تو نیوکلیس اس کو ایسا نہیں کرنے دے گا۔ یاد رکھیں یہ 1913 میں بوہر نے کہا تھا کیونکہ یہ اُس کا مفروضہ تھا۔)

Q.20 How do you justify that the distances between adjacent orbits of H atom go on increasing from lower to the higher orbits? (Guj. 2013, Multan 2014)

-20 آپ کیسے ثابت کریں گے کہ بوہر کے ماڈل کے مطابق آربٹس کے فاصلے بڑھتے چلے جاتے ہیں؟

Ans: In the equation for the radius of the H-atom, after putting the values of different parameters for H-atom is as follows

$$r = 0.529\,(n^2)\ A^\circ \qquad \boxed{1A^\circ = 10^{-10}\ m}$$

If we put the value of "n" = 1, 2, 3, ..., we can get the radii which show that the distances (فاصلے) between adjacent orbits (ساتھ ساتھ والے آربٹس) go on increasing.

$$r_1 = 0.529\ A^\circ$$

$$r_2 = 2.14\ A^\circ$$

$$r_3 = 4.7\ A^\circ$$

$$r_4 = 8.4\ A^\circ$$

Q.21 How do you justify that the radius of orbit in H-atom is directly proportional to the square of number of orbit?

-21 کس طرح ثابت کریں گے کہ H ایٹم کے آربٹس کے نصف قطر آربٹ کے نمبر کے مربع کے سیدھے متناسب ہیں؟

Ans. When we derive (اخذ کرنا) the equation for radius of an atom according to Bohr's model, we get the following equation

$$r = 0.529\left(\frac{n^2}{Z}\right) A^\circ$$

According to this equation, radius is directly proportional to square of number of orbit. So when the number of orbit increases the radius increases sharply. Second Bohr's orbit is four times away from the nucleus than the 1st orbit (دوسرا آربٹ پہلے آربٹ سے چار گنا نیوکلیس سے دور ہے). Third orbit is nine times away (تیسرا آربٹ نو گنا دور ہے).

Q.22 How do you justify that radius of orbit in H-atom is inversely proportional to the number of protons in the nucleus?

-22 کیسے ثابت کریں گے کہ H-ایٹم کے آربٹس کے نصف قطر نیوکلیس میں پروٹانز کی تعداد کے الٹ متناسب ہیں؟

Ans. According to the above equation, radius is inversely proportional (اُلٹ متناسب) to the number of protons in the nucleus. Greater the number of protons, smaller the radius. *i.e.* $He^{\oplus}$ has two protons in the nucleus, so its 1st orbit is at half a distance than hydrogen atom. Hence $He^{\oplus}$ ion is smaller than that of hydrogen atom.

H ایٹم $He^{\oplus}$ سے کم نصف قطر والا ذرہ ہے۔

Q.23 How do you prove that the energy associated with the electron which is revolving around the nucleus of H-atom is negative?

(Guj. 2010, Bahawalpur 2011)

-23 ثابت کریں کہ نیوکلیس کے گرد چلتے الیکٹران کی انرجی منفی میں ظاہر کی جاتی ہے۔

Ans: The expression for the potential energy (مخفی انرجی) of electron is

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

The value of the kinetic energy is calculated from the equalization (برابر کرنے کا عمل) of force of attraction $\left(\frac{Ze^2}{4\pi\epsilon_0 r^2}\right)$ and centrifugal force (مرکز گریز قوت), $\left(\frac{mv^2}{r}\right)$

So, $\frac{1}{2} mv^2 = K.E. = \frac{Ze^2}{8\pi\epsilon_0 r}$

When we add K.E. and P.E. the total energy is negative.

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

Q.24 How do you come to know that the velocities of electrons in higher orbits are less than those in lower orbits of hydrogen atom?

(Model Paper-2006-07, Rwp. 2008, D.G. Khan 2011, Lahore 2012, Rwp. 2014)

-24 آپ کو کیسے پتہ چلا کہ الیکٹران کی رفتار اوپر والے آربٹس میں کم ہے اور نیچے والوں میں زیادہ ہے۔

Ans. According to Bohr's proposals, the centrifugal force (مرکز گریز قوت) 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,

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

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

(جتنا الیکٹران تیز حرکت کرے گا اتنا نیوکلیس کے قریب آئے گا۔ آپ کو پتہ ہے کہ وہ سیارے جو سورج کے قریب ہیں اُن کی رفتار زیادہ ہے۔)

Q.25 Energy of an electron is inversely proportional to 'n²' but energy of higher orbits are always greater than those of the lower orbits. Why?

(Lahore 2012)

-25 الیکٹران کی انرجی n^2 کے الٹ متناسب ہے۔ لیکن اوپر والے آربٹس کی انرجی زیادہ ہوتی ہے۔ کیوں؟

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

$$E = -2.18 \times 10^{-18} J \left(\frac{1}{n^2}\right)$$

Greater the value of 'n' greater the value of energy because energy is negative inverse of n (انرجی n^2 کا اُلٹ منفی کے ساتھ ہے). It becomes more and more, 'less' negative (یہ زیادہ سے زیادہ کم منفی ہوتا جاتا ہے). The value of energy approaches zero, when $n = \infty$

Q.26 The energy difference between adjacent levels goes on decreasing sharply. Why? (Rawalpindi 2007)

-26 جب ہم نیچے سے اوپر والے آربٹس میں جاتے ہیں تو ساتھ ساتھ والے آربٹس کی انرجی کا فرق تیزی کے ساتھ کم ہوتا چلا جاتا ہے۔ کیوں؟

Ans. If we put the value of n as 1,2,3,4 we get the energies of various orbits of hydrogen atom. These values are as follows:

$$E_1 = -2.18 \times 10^{-18} \text{ J}$$
$$E_2 = -0.54 \times 10^{-18} \text{ J}$$
$$E_3 = -0.24 \times 10^{-18} \text{ J}$$
$$E_4 = -0.14 \times 10^{-18} \text{ J}$$

So $E_2 - E_1 > E_3 - E_2 > E_4 - E_3$ ..... and so on.

As is clear from these values that energy differences (انرجی کے فرق) between adjacent levels go on decreasing (کم ہوتے جاتے ہیں) from lower to the higher levels.

Q.27 Justify that the distance gaps between different orbits go on increasing from the lower to the higher orbits. (Faisalabad 2007, Sarg. 2009)

-27 یہ صحیح ثابت کریں کہ جب ہم نیچے سے اوپر والے آربٹس میں جاتے ہیں تو فاصلوں کے فرق زیادہ ہوتے چلے جاتے ہیں۔

Ans. According to Bohr's model the radius of an orbit is proportional (متناسب ہونا) to the square of number of orbit.

$$r = 0.529 \left(\frac{n^2}{Z}\right) A^\circ$$

For hydrogen atom Z = 1

Putting the values

$$r = 0.529 \left(\frac{n^2}{Z}\right) A^\circ$$
$$r_1 = 0.529\ A^\circ$$
$$r_2 = 2.4\ A^\circ$$
$$r_3 = 4.8\ A^\circ$$
$$r_4 = 8.4\ A^\circ$$

The difference of the adjacent orbit are such that (ساتھ ساتھ آربٹس کے فاصلوں کے فرق یہ ہیں)

$$r_2 - r_1 < r_3 - r_2 < r_4 - r_3$$

Q.28 How Bohr's model of H-atom can help us to justify the ionization potential of H-atom? (B.P. 2008, Guj. 2010)

-28 کس طرح بوہر کے ایٹم کا ماڈل ہائیڈروجن کے آربٹ سے مکمل طور پر الیکٹران نکالنے کی انرجی کا ہمیں حساب لگا کر بتاتا ہے؟

Ans: The formula for the energy difference between any two levels for H-atom is

$$\Delta E = +2.18 \times 10^{-18} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) J$$

This is the equation for one atom of hydrogen. If we multiply this by Avogadro's number and divide by 1000, we get the following equation

$$\Delta E = +1313.315 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) kJ\ mol^{-1}$$

If we put the values of $n_1 = 1$ and $n_2 = \infty$, then we can get the ΔE value for the ionization of H-atom

$$\Delta E = +1313.315\left(\frac{1}{n_1^2} - \frac{1}{\infty^2}\right) = 1313.315 \text{ kJ mol}^{-1}$$

کیونکہ جب کسی ایٹم کے آربٹ سے الیکٹران لے کر اتنے دور لے جائیں کہ ان کی کشش کی قوت ختم ہو جائے تو ہم کہتے ہیں $n = \infty$ ہے۔ یہی قیمت H کے ایک مول کی I.E. ہے۔ موجودہ تجربات نے اِس کو کنفرم کر دیا ہے۔

Q.29 How does Bohr's equation give us the wave number of photon, which is emitted or absorbed during jumping of electron between two orbits?

-29 بوہر کے ایٹم کا ماڈل اس فوٹان کا ویو نمبر کس طرح بتاتا ہے؟ جو الیکٹران کے آربٹس بدلنے سے نکلتا یا جذب ہوتا ہے۔

Ans: Bohr derived an equation for the wave number of photon, which is emitted or absorbed when the electron jumps between any two orbits

$$\bar{\upsilon} = 1.09678 \times 10^{+7}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) m^{-1}$$

By putting the values of n_1 and n_2 for any two orbits, we can calculate the wave number of the photon emitted or absorbed.

Q.30 Hydrogen atom and $He^{\oplus}$ are monoelectronic system, but the size of $He^{\oplus}$ is much smaller than H. Why? (Multan 2009)

-30 H ایٹم اور $He^{\oplus}$ آئن ایک ایک الیکٹران رکھنے والی چیزیں ہیں۔ لیکن $He^{\oplus}$ کا سائز H کے مقابلہ میں بہت ہی کم ہے۔ کیوں؟

Ans. Hydrogen atom and $He^{\oplus}$ ion have single electron in the valance shell (وہ شیل جس میں پڑے ہوئے الیکٹرانز ویلنسی کا فیصلہ کرتے ہیں) but $He^{\oplus}$ has two protons in the nucleus, so it will have greater force of attraction. The size of $He^{\oplus}$ is smaller than H atom.

$$r_{He^{\oplus}} = 0.529\left(\frac{1^2}{2}\right) A^\circ = 0.2645\ A^\circ$$

Q.31 Do you think that the size of Li^{+2} is even smaller than $He^{\oplus}$? Justify with calculations.

-31 آپ کا کیا خیال ہے کہ Li^{+2} کا سائز $He^{\oplus}$ سے بھی کم ہے۔ حساب کر کے صحیح ثابت کریں۔

Ans. The size of Li^{+2} is even smaller than $He^{\oplus}$, because Li^{+2} has three protons in the nucleus it has only one electron. So,

$n = 1$ and $Z = 3$

$$r_{Li^{2+}} = 0.529\left(\frac{1^2}{3}\right) A^\circ = \frac{0.529}{3} A^\circ = 0.176 A^\circ$$

Q.32 How the value of the Redberg's constant can be justified from Bohr's equation?

-32 رڈبرگ کے مستقلہ کو بوہر کی مساوات کس طرح صحیح ثابت کرتی ہے؟

Ans: The constant outside the brackets was called Redberg's constant (بریکٹس کے باہر والا مستقلہ کو رڈبرگ کا مستقلہ کہتے ہیں) and was denoted by "R". Its value was deduced by the back calculations from the experimental data of Lyman and Balmer series, by Redberg and Balmer both around 1887. Anyhow, the structure of atom was not clear at that time.

Bohr gave the following relationship for the wave number

$$\bar{\upsilon} = \frac{Z^2 me^4}{8\epsilon_0^2 h^3 c}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) m^{-1}$$

The solved factor outside the brackets comes out equal to Redberg's constant *i.e.*,

$$\frac{Z^2 me^4}{8\epsilon_0^2 h^3 c} = 1.09678 \times 10^{+7}\ m^{-1}.$$

Q.33 Write down the equation for energy difference of two orbits of hydrogen atom.

-33 ہائیڈروجن کے کوئی سے دو آربٹس کے انرجی کے فرق کے لئے مساوات لکھیں۔

Ans: A formula for energy difference of any two orbits of hydrogen atom given by Bohr is

$$\Delta E = \frac{mZ^2e^4}{8\epsilon_0^2 h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Delta E = 2.18 \times 10^{-18}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] J$$

n_1 is the lower orbit and n_2 is higher orbit. Other factors are constant for an atom.

Q.34 What are defects of Bohr's atomic model?
(Multan 2005, Guj. 2008, B.P.2008, Sarg. 2011, F. Abad 2012, Sarg. 2014, Guj. 2014, Sahiwal 2014)

-34 بوہر کے ایٹمی ماڈل کے نقائص بیان کریں۔

Ans: It is only applicable (لگتا ہے) to hydrogen atom, $He^{\oplus}$, $Li^{(+2)}$ and $Be^{(+3)}$ to understand their spectra It cannot explain the fine structure of hydrogen atom (ہائیڈروجن ایٹمز کے سپکٹرا میں باریک لائنز). The explanations of Zeeman effect and Starck effects are also not available from this model.

Q.35 Why does the fine structure of H-atom in its spectrum finds no explanation from Bohr's model? (Model Paper)

-35 H-ایٹم کے سپکٹرا میں جو نفیس لائنز آتی ہیں اُن کی بوہر کا ماڈل کیوں ثابت نہیں کر سکتا۔

Ans: When the spectroscopes (وہ آلات جن سے سپکٹرا کی پیائش کرتے ہیں) of high resolving powers (زیادہ تفصیل سے بتانے کی صلاحیت والی) were used, then some new lines were also recorded on the photographic plate for H-atom. These lines were very weak. The appearance (ظاہر ہونے کا عمل) of the weak lines was called the fine structure of H-atom. Bohr could not find any quantum number to justify these fine lines.
(بوہر ان نفیس اور باریک لائنز کے لئے کوئی نیا کوانٹم نمبر نہ دے سکا۔)

Q.36 What is Zeeman effect? (Rawalpindi 2007, Guj. 2009, Guj. 2010, D.G. Khan 2011, Faisalabad 2011, B. Pure 2012, Multan 2013, B. Pure 2013, B. Pur 2014, F. Abad 2014)

-36 Zeeman کا اثر کیا ہوتا ہے؟

Ans: When the light of spectral lines is passed through the magnetic field (مقناطیسی میدان), then the one spectral line is splitted up (ٹوٹ جاتی ہے) into many spectra lines. This splitting of the spectral line cannot be explained by Bohr's theory.

Q.36A What is Starch effect? (Multan 2008, Guj. 2009, Guj. 2010, D.G. Khan 2011, Faisalabad 2011, B. Pure 2012, B. Pure 2013)

-36A سٹارک کا اثر بیان کریں۔

Ans: When the light of spectral lines is passed through the electrical field (برقی میدان), then the one spectral line is split up (ٹوٹ جاتی ہے) into many spectra lines. This splitting of the spectral line cannot be explained by Bohr's theory.

Spectra

Q.37 What is line spectra of hydrogen and how it differs from contineous spectrum? (Rwp. 2010, Multan 2012, D. G. Khan 2012, D.G. Khan 2013, Faisalabad 2013, Lahore 2014, Lhr 2014)

-37 ہائیڈروجن کا لائن سپکٹرا کیا ہوتا ہے یہ کس طرح تسلسل والے سپکٹرا سے مختلف ہے؟

Ans: Hydrogen absorbs certain photons of light to promote (آگے لے کر جانا) the electron from its lower energy level to high energy levels. These photons do not reach the photographic plate (فوٹوگرافی والی پلیٹ پر), so line spectra is obtained. The spectra of ordinary light is contineous (متواتر ہے) because all the photons reach the photographic plate and no frequency is absorbed on its way.

Q.38 The energy associated with the violet colour is greater than the red colour in the visible region of spectra. Why? (Lahore 2007)

-38 وائولٹ رنگ کے ساتھ جو توانائی وابستہ ہے وہ سرخ رنگ سے زیادہ کیوں ہے؟

Ans: The photons of violet colour (بنفشی رنگ) bend to the maximum extent after passing through the prism (شیشے کا منشور) and their range of wavelength is from 400 – 420 nm. They have high energy and have shorter wavelengths. The photons of the red colour have the longer wavelength ranging from 630 to 800 nm. These photons bend in the prism to lesser extent (کم حد تک).

Q.39 Why the photographic plate is white and few dark lines are there in the line absorption spectra of a substance?
(Model Paper-2006-07, Sarg. 2009, Lahore 2010, Sarg. 2011, B. Pure 2012)

-39 کسی چیز کے Line absorption سپکٹرا میں چند کالی لائنز موجود ہوتی ہیں اور باقی ساری فوٹوگرافک پلیٹ سفید کیوں ہوتی ہیں؟

Ans: Some of the photons are absorbed by the sample to excite (غصہ دلاتے ہیں) the electrons of a substance from lower energy levels to higher energy levels. These photons of light don't reach the photographic plate (فوٹوگرافک پلیٹ پر یہ جذب شدہ فوٹانز نہیں پہنچ پاتے ان جگہوں پر کالی لائنز آئیں گی۔). Rest of the light reaches the photographic plate, so the plate is white. Only those places are dark in the form of sharp lines (تیز لائنز) where the photon don't reach.

Q.40 Why the photographic plate is dark and a few bright lines are there in the line emission spectra of hydorgen?
(Sargodha 2009, Rwp. 2010, Sarg. 2011, B. Pure 2012, Sarg. 2014)

-40 H کے Line emission سپکٹرا میں چند روشن لائنز موجود ہوتی ہیں جبکہ باقی ساری پلیٹ کالی کیوں ہوتی ہیں؟

Ans: The sample of hydrogen is taken in a glass tube. Electric current (برقی رو) is passed through the gas. Electrons of the atoms or molecules are excited to higher energy levels. These electrons fall back (واپس گرتے ہیں) to the original levels (پہلے لیولز میں) and emit the photons of light. These emitted photons produce bright lines (یہ نکلنے والے فوٹانز سفید لائنز دیتے ہیں) and rest of the plate is dark.

Q.41 How Bohr's model justifies the H-spectra. (Faisalabad 2010, Lahore 2011)

-41 بوہر کا ماڈل H- کے سپیکٹرا کو کیسے صحیح ثابت کرتا ہے؟

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

Q.42 What is H_α-line in hydrogen spectrum? (Bahawalpur 2011)

-42 ہائیڈروجن کے سپیکٹرا میں H_α لائن کیا ہوتی ہے؟

Ans: This is the first line of Balmer series. It is produced due to the jumping of electrons from n = 3 to n = 2. This line lies in the visible region. This line was noted experimentally in 1887, but got its justification on theoretical basis in 1913 by Bohr.

Q.43 Indicate the limiting line of Balmer series.

-43 Balmer کی لائینوں کے تسلسل میں آخری حدود والی لائن کا تعین کریں۔

Ans: When the electrons jump from an infinite orbit (n = ∞) to n = 2 of hydrogen atom, then this line on the photographic plate is called the limiting line (حدود والی لائن). It has high energy and lies in the visible resion.

Q.44 How is atomic emission spectrum obtained?
(Bahawalpur Board 2005, Rawalpindi Board 2005, B. Pure 2013)

-44 کسی ایٹم کا emission سپیکٹرا کیسے حاصل کیا جاتا ہے؟

Ans: The substance is heated in a glass tube by the electrical spark (برقی برتیرے سے). The electrons are excited (برانگیختہ ہوتے ہیں) to higher energy levels and when they come back, they emit the photons of light. These emitted photons (نکالے گئے فوٹانز) are recorded on the photographic plate. The whole plate is dark alongwith the few bright lines. The collection of these bright lines is called line emission spectrum of the substance.

X-Rays

Q.45 The x-rays produced in a discharge tube experiment are characteristic of the target metal. How? (R. Pindi 2012, Rwp. 2014)

-45 ڈسچارج ٹیوب میں x-rays پیدا ہوتی ہیں وہ اس میٹل کی صفات پر انحصار کرتی ہیں۔ جس پر کیتھوڈ ریز گر رہی ہیں۔ کیسے؟

Ans: The wavelength of the x-rays which are emitted from the surface of the metal (جو میٹل کی سطح سے نکلتی ہیں x-rays) depend upon the atomic number of the metal. Greater the number of protons in the nucleus of metal atom greater the forces of attraction for the inner electrons. Greater the energy differences (توانائی کا فرق), smaller the wavelength of x-rays. X-rays are emitted due to jumping of electrons from higher levels to n = 1, the vacant level.

Q.46 What is Moseley's law?
(F.Abad 2007, Multan 2007, Rwp.2007, F. Abad 2008, Lah 2009, Guj. 2009, Sarg. 2010, Faisalabad 2010, Rwp. 2010, Lahore 2011, F. Abad 2012, M. Pure 2012, Lahore 2012, D.G. Khan 2012, R. Pindi 2012, Multan 2013, D.G. Khan 2013, B. Pur 2014, Sarg. 2014, F. Abad 2014, Lahore 2014)

-46 Mosely کا قانون بیان کریں۔

Ans: Moseley's law is the relationship (تعلق) between the frequency of a line of spectrum of x-rays with the atomic number of the target metal (وہ دھات جس پر کیتھوڈ ریز گر رہی ہیں).

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

where 'a' and 'b' are constants. This is an equation of straight line. ν is frequency and Z is atomic number of target metal and 'b' is screening constant.

Q.47 Why do we say that the graphs obtained from the Moseley's law are straight lines? (Lahore 2009, Faisalabad 2010, Rwp. 2010, Multan 2013, F. Abad 2014, Sarg. 2014)

-47 ہم کیسے کہتے ہیں کہ مُوضلے کے قانون کے مطابق گراف سیدھی لائنز دیتے ہیں؟

Ans: According to Moseley's law, the square root of the frequency of the spectral lines (سپکٹرا کی لائنز کا تعدد کا جذر) of characteristic x-ray spectrum of an element varies directly to the atomic number of the element producing the spectrum. Mathematically

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

'a' and 'b' are constants. When $\sqrt{\upsilon}$ is plotted against "Z" then the straight line is obtained.

de-Broglie's Dual Nature of Matter

Q.48 How the idea of dual nature of matter was deduced from the dual nature of light? (Bahawalpur 2007, Multan 2008, B.P. 2008, Sarg. 2011)

-48 روشنی کے دوہرے کردار سے کس طرح مادہ کے دوہرے معیار کا خیال جنم لیتا ہے؟

Ans: According to Planck's quantum theory and mass energy relationship, we can say that

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

de-Broglie proposed that matter and energy should behave in a similar manner, because nature is symmetrical (مادے اور انرجی کو ایک طرح سلوک کرنا چاہیے کیونکہ قدرت کے کام میں ایک جیسا پن ہے). So, he says that the wavelength associated with the electron (الیکٹران کی لہر کی لمبائی) is inversely proportional to the momentum (معیارِ حرکت کے الٹ متناسب ہے) of the electron

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

Q.49 According to de-Broglie's idea, only microscopic particles have the waves. How waves were measured? (Bahawalpur 2007, Sargodha 2008, Multan 2008, B.P. 2008, Guj. 2014)

-49 de-Broglie کے خیال کے مطابق صرف وہ ذرات لہریں بناتے ہیں۔ جو صرف خوردبین سے ہی دیکھے جا سکتے ہیں۔ یہ لہریں کیسے پیمائش کی گئی ہیں۔

Ans: Keeping in view de-Broglie's equation for dual nature of matter (مادے کی دوہری فطرت), the wavelength is inversely proportional to the mass of the particle

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

For a stone of 100 gm moving with the velocity 10 ms^{-1}, the wavelength associated with that is 6.65×10^{-30} m. This wavelength cannot be measured by any instrument. In the case of electron moving with the velocity of $6 \times 10^{+5}$ ms^{-1}, the wavelength associated with that is 1.1 nm which can be easily measured by the instrument.

Davisson and German devised an experiment in which electrons of cathode rays were thrown on Ni-crystal and diffraction was studied.

Wave Mechanical Model of Atom

Q.50 What are the basis of Schrodinger wave equation?

-50 شروڈنگر کی لہری مساوات کی بنیادیں کیا ہیں؟

Ans:
(i) Electron behaves like a wave.
(ii) Heisenberg's uncertainty principle is obeyed.
(iii) We can only talk about the probability (امکانات) of electron.

Q.51 Heisenberg's uncertainty principle has no relation with Bohr's atomic model. Justify it.

(Model Paper-2006-07, Bahawalpur 2011, Multan 2012, F. Abad 2012, Guj. 2013, Federal Board 2013, Multan 2014)

-51 ہائزن برگ کے بے یقینی والے اصول کا بوہر کے ماڈل سے کوئی تعلق نہیں ہے۔ صحیح ثابت کریں۔

Ans: Since the electron has wavy nature (لہری فطرت) and paths are elliptical (بیضوی شکل کے) as well, so the simultaneous (ایک ہی وقت میں) determination of position and momentum is not possible. But Bohr's model does not accommodate (جگہ نہ دینا) the wavy nature of electron. He says that the paths are fixed orbits and their orbits are planar. It means that Bohr's model is very simple as compared to Heisenberg's uncertainty principle.

Q.52 What is the function of principal quantum number?

(AJK 2005, Guj. 2008, Fd. 2009, Sahiwal 2014, Lahore 2014)

-52 پرنسپل کوانٹم نمبر کا کیا کام ہے؟

Ans: Its values are whole numbers and never zero, negative or fractional. It gives us information about:
(i) energy of electron (الیکٹران کی انرجی).
(ii) distance of electron from the nucleus (نیوکلس سے الیکٹران کا فاصلہ).

Q.53 What is the function of azimuthal quantum number?

(Sargodha 2008, Sargodha. 2011, D.G. Khan 2012, Lahore 2014, Sarg. 2014)

-53 ایضی موتھل کوانٹم نمبر کس کام آتا ہے؟

Ans: This quantum number (l) gives us the shape of the orbital.

For $l = 0$, s-orbital
$l = 1$, p-orbital
$l = 2$, d-orbital
$l = 3$, f-orbital

Its value also determine the energy of electron. When l = 3, then m has ±3, ±2, ±1, 0 values.

Q.54 Calculate the number of electrons in s, p, d and f sub-shells from the formula. **(Sargodha Board 2005)**

-54 فارمولہ کی مدد سے بتائیں کہ s, p, d اور f سب شیلز میں کتنے کتنے الیکٹرانز آتے ہیں؟

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

For	s-orbital	$2(2 \times 0 + 1)$	=	2 electrons
For	p-orbital	$2(2 \times 1 + 1)$	=	6 electrons
For	d-orbital	$2(2 \times 2 + 1)$	=	10 electrons
For	f-orbital	$2(2 \times 3 + 1)$	=	14 electron

Q.55 The magnetic quantum number gives us the orientation of orbital in space. Justify it.

-55 میگنیٹک کوانٹم نمبر کس طرح آربیٹال کی سپیس میں سمتیں بتاتا ہے؟ ثابت کریں۔

Ans: In order to designate (ماموز کرنا) the directions of p-orbitals (آربیٹال کی سمتیں-p) in p-subshell, we need an additional quantum number and that is called magnetic quantum number. It tells us the orientation of orbital in space (آربیٹالز کی سپیس میں ایک دوسرے کے لحاظ سے پوزیشن). p-subshell has three orbitals and they have three directions in space. For each direction there is a separate value of magnetic quantum number.

Q.56 Define Hund's rule? (Lahore Board 2005, Mirpur-2006, M. Pure 2012, D.G. Khan 2012, Faisalabad 2013, Multan 2013, B. Pure 2013, Rwp. 2013, D.G. Khan 2013, D.G. Khan 2014, B. Pur 2014, Sarg. 2014, Lahore 2014)

-56 Hund کے رول کی تعریف کریں۔

Ans: This rule is concerned with the distribution of electrons (الیکٹرانز کی تقسیم) in degenerate orbitals (برابر انرجی والے آربیٹالز). These orbitals may be atomic or molecular. According to this rule **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.**

Q.57 Define atomic number? Write the electronic configuration of oxygen? (Lahore Board 2005)

-57 ایٹمی نمبر کی تعریف کریں۔ ایٹم کے الیکٹرانز کی تقسیم لکھیں۔

Ans: Atomic number is the number of electrons and protons in an atom. Oxygen has eight electrons and has the electronic configuration as follows:

$$_8O = 1s^{\uparrow\downarrow}\ 2s^{\uparrow\downarrow}\ 2p_x^{\uparrow}\ 2p_y^{\uparrow}\ 2p_z^{}$$

Q.58 State Pauli's exclusion principle and Hund's rule?
(Gujranwala Board 2005, D.G. Khan-2006, Federal-2006, Bahawalpur-2006, Lahore 2007, Lahore 2008, Lahore 2010, Guj. 2011, Lahore 2012, Lahore 2014, , Lahore 2014, , Lahore 2014,)

-58 پالی کا اصول اور ہنڈز کا قانون بیان کریں۔

Ans: According to Pauli's principle **no two electrons in an atom can have the same set of four quantum numbers** (ایک ایٹم کے اندر جتنے بھی الیکٹرانز ہوتے ہیں ہر الیکٹران کا کوانٹم نمبرز کا ایک سیٹ ہوتا ہے۔ کسی ایک الیکٹران کا سیٹ دوسرے سے نہیں ملتا). According to Hund's rule, if degenerate orbitals are available and more than two electrons are to be palced in them, then place them in separate orbitals with the same spins rather than in the same orbital with the opposite spins.

Q.59 What is (n + l) rule? Wrtie electronic configuration of elements: (i) $_{29}Cu$ (ii) $_{19}K$ and (iii) $_{24}Cr$.
(Lahore 2008, Fd. 2009, Faisalabad 2011, Rwp. 2011, Guj. 2013, Faisalabad 2013, F. Abad 2014, Lahore 2014, D.G. Khan 2014)

-59 Cu اور K کے الیکٹرانز کی تقسیم لکھیں۔

Ans: To determine the energy position of an electron, we take the sum of principal and azimuthal quantum number.

$$_{29}Cu = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{\uparrow\downarrow}\ 3d^{\uparrow\downarrow}\ 3d^{\uparrow\downarrow}\ 3d^{\uparrow\downarrow}\ 3d^{\uparrow\downarrow}$$

$$_{19}K = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$$

$$_{24}Cr = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$$

Q.60 What will be the position of electron in an atom when (n + l) value is same for two sub-shells? (Rawalpindi 2008)

-60 جب دو سب شیلز کی (n + l) کی قیمت برابر ہو تو الیکٹران کو پہلے کس میں رکھتے ہیں؟

Ans: The electron will be accommodated (جگہ مل جائے گی) in that orbital whose 'n' value is smaller.

Q.61 Write the electronic configuration of $_{20}Ca$ and $_{35}Br$.

(D.G. Khan 2011, D.G. Khan 2014, Lahore 2014)

-61 $_{20}Ca$ اور $_{35}Br$ کے الیکٹرانز کی تقسیم لکھیں۔

Ans: $_{20}Ca = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

$_{35}Br = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^5$