Solution

STRUCTURE OF ATOM WS 1

Class 11 - Chemistry

1.

(d) C, N, O, F, Ne
Explanation: C, N, O, F, Ne

2.

(d) 3.98×10^{-15}J
Explanation: Energy (E) of a photon having wavelength (λ) is given by the expression, $E = \frac{hc}{\lambda}$ where, h = Planck's constant = $6.626 \times 10^{-34} Js$
c = velocity of light in vacuum = $3 \times 10^8 m/s$
Wavelength $\lambda = 0.50 A^\circ = 0.50 \times 10^{-10} m$
Substituting the values in the given expression of E as
$= \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{0.50 \times 10^{-10}} = 3.98 \times 10^{-15} J.$

3. **(a)** shielding of the outer shell electrons from the nucleus by the inner shell electrons
Explanation: Shielding effect can be defined as a reduction in the effective nuclear charge on the electron cloud, due to a difference in the attraction forces of the electrons on the nucleus. It is also referred to as the screening effect (or) atomic shielding.

4.

(c) n = 3 to n = 1
Explanation: $\bar{\nu} = \frac{1}{\lambda} = RZ^2(\frac{1}{n_1^2} - \frac{1}{n_2^2})$
where λ is the wavelength of the photon
$\bar{\nu}$ is wave number
R = Rydberg's constant
Z = atomic number of the atom
n_1 and n_2 are integers where $n_2 > n_1$.
For hydrogen, Z = 1.
So, when Electron jump from n=3 to n=1
$\bar{\nu} = R(\frac{1}{1^2} - \frac{1}{3^2}) => \bar{\nu} = R(1 - \frac{1}{9}) = \frac{8}{9}R$

5.

(c) 8.72×10^{-18}J atom^{-1}
Explanation: He^+ ion is a single electron species which resembles like hydrogen. Therefore, the energies of the stationary states of hydrogen-like ions are given by the expression
$E_n = 2.18 \times 10^{-18} \times \frac{Z^2}{n^2}$
Here n = 1 and Z = 2
$E_n = 2.18 \times 10^{-18} \times \frac{2^2}{1^2}$ = 8.72×10^{-18}J atom^{-1}

6. **(a)** Boron
Explanation: Boron is a chemical element with symbol B and atomic number 5. So electronic configuration of boron is $1s^2 2s^2 2p^1$

7.

(d) -8.68×10^{-20} J/atom
Explanation: The energy of first (Bohr) orbit in hydrogen atom = -2.17×10^{-18}Jatom^{-1}
The energy of the fifth orbit will be given by $E_n = E_1 \times \frac{Z^2}{N^2}$
$E_5 = \frac{-2.17 \times 10^{-18}}{5^2} = -8.68 \times 10^{-20} Jatom^{-1}$.
The energy of the fifth orbital = $= -8.68 \times 10^{-20} Jatom^{-1}$

8.

(d) $\bar{\nu} = 109,737\left(\frac{1}{\mathrm{n}_1^2} - \frac{1}{\mathrm{n}_2^2}\right)$

Explanation: In an amazing demonstration of mathematical insight, in 1885 Balmer came up with a simple formula for predicting the wavelength of any of the lines in atomic Hydrogen in what we now know as the Balmer series.

Three years later, Rydberg generalized this so that it was possible to determine the wavelengths of any of the lines in the hydrogen emission spectrum. Rydberg suggested that all atomic spectra formed families with this pattern (he was unaware of Balmer's work).

It turns out that there are families of spectra following Rydberg's pattern, notably in the alkali metals, sodium, potassium, etc., but not with the precision the hydrogen atom lines fit the Balmer formula, and low values of n_2 predicted wavelengths that deviate considerably.

Rydberg's general equation is as follows:

$\bar{\nu} = \frac{1}{\lambda} = R_h\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

where

- R_H is the Rydberg constant and is 1,09,677 cm^{-1}
- n_1 and n_2 are integers (whole numbers) with $n_2 > n_1$

9. **(a)** Rydberg's constant

Explanation: The Rydberg constant, symbol R_∞ for heavy atoms or R_H for hydrogen, named after the Swedish physicist Johannes Rydberg, is a physical constant relating to atomic spectra, in the science of spectroscopy.

10.

(b) Fe^{3+}, Mn^{2+}

Explanation: Explanation: Fe(Z-26: $3d^6 4s^2$) and Mn (Z-25: $3d^5 4s^2$)

Fe^{3+}: $3d^5$ and Mn^{2+}: $3d^5$ will have the same no. of electrons and hence, the same electronic configuration.

11. **(a)** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$

Explanation: Number of electron (29) = Number of protons (29)

So electronic configuration = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$

12.

(c) transition from excited to normal state

Explanation: The emission spectrum of a chemical element or chemical compound is the spectrum of frequencies of electromagnetic radiation emitted due to an atom or molecule making a transition from a high energy state to a lower energy state. The photon energy of the emitted photon is equal to the energy difference between the two states. There are many possible electron transitions for each atom, and each transition has a specific energy difference. This collection of different transitions, leading to different radiated wavelengths, makes up an emission spectrum.

13.

(c) energy of quantum

Explanation: Max Planck theorized that energy was transferred in chunks known as quanta, equal to $h\nu$. The variable h is a constant equal to 6.63 $\times$ 10^{-34} J·s and the variable νrepresents the frequency in 1/s.

This equation allows us to calculate the energy of photons, given their frequency.

If the wavelength is given, the energy can be determined by first using the wave equation$(c = \lambda \times \nu)$to find the frequency, then using Planck's equation to calculate energy.

14.

(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9\ 4s^2$

Explanation: Correct electronic configuration of the two subshells (3d and 4s) should be 3 $d^{10}4s^1$

In certain elements such as Cu or Cr, where the two subshells (4s and 3d) differ slightly in their energies, an electron shifts from a subshell of lower energy (4s) to a subshell of higher energy (3d), provided such a shift results in all orbitals of the subshell of higher energy getting either completely filled or half-filled. Therefore it is wrong.

15.

(c) electron microscope

Explanation: The electron microscope uses a beam of accelerated electrons as a source of illumination. The wavelength of an electron being much shorter than the visible light the electron microscope has a higher resolving power.

16. **(a)** $2n^2$

Explanation: Since the maximum number of electrons in each orbital is 2, the maximum number of electrons in an entire quantum level is $2n^2$.

17.

(d) Paschen series

Explanation: The Lyman series lies in the ultraviolet, whereas the Paschen, Brackett, and Pfund series lies in the infrared.

18.

(d) 1.72×10^6 m^{-1}

Explanation: Wave number is defined as the reciprocal of the wavelength.

$\bar{\nu} = \frac{1}{\lambda}$

where, λ = wavelength =5800Å $= 5.8 \times 10^{-7} m$

$\bar{\nu} = \frac{1}{5.8 \times 10^{-7}}$ = $1.72 \times 10^6 m^{-1}$

19.

(d) the splitting of emission lines in a Magnetic field

Explanation: In 1920, Otto Stern and Walter Gerlach designed an experiment, which unintentionally led to the discovery that electrons have their own individual, continuous spin even as they move along their orbital of an atom. The experiment mentioned above by Otto Stern and Walter Gerlach was done with silver which was put in an oven and vaporized. The result was that silver atoms formed a beam that passed through a magnetic field in which it split in two.

20. **(a)** (3p) < (4s) < (3d) < (4p).

Explanation: Energy of the orbital is determined by the n+l value. The orbital having a higher n+l value will have higher energy. If n+l value is the same then orbital having a higher n value will have higher energy.

21.

(b) Balmer series

Explanation: The spectral lines which arise due to the transition of electrons from higher energy levels to the second energy level will appear in the visible region. Balmer series lies in the visible region of the EM spectrum.

22.

(c) Violet

Explanation: Waves with a short wavelength have the most energy. Red waves have a relatively long wavelength (in the 700 nm range), and violet waves are much shorter - roughly half that. Because violet waves have the shortest wavelength of the visible light spectrum, they carry the most energy.

23.

(d) 1.988×10^{-18}J

Explanation: We know Planck's equation is $E = h\nu$

where E is energy, h is Planck's constant and ν is frequency.

Put the given values,

E = $6.626 \times 10^{-34} \times 3 \times 10^{15} = 1.988 \times 10^{-18} J$

24.

(b) 3.98×10^{-15} J

Explanation: Energy (E) of a photon having wavelength (λ) is given by the expression, $E = \frac{hc}{\lambda}$

where, h = Planck's constant = 6.626×10^{-34}

c = velocity of light in vacuum = 3×10^8 m/s

Wavelength $\lambda = 0.50 A^\circ = 0.50 \times 10^{-10} m$ λ = 0.50 Å = 0.50×10^{-10} m

Substituting the values in the given expression of E:

$\frac{6.626 \times 10^{-34} \times 3 \times 10^8}{0.50 \times 10^{-10}}$ = 3.98×10^{-15} J

25.

(d)

- n = 1, 2, 3..
- l = 0, 1,.. n-1;
- ml = -l,-l+1, ..0,1..l-1, l

Explanation: n (Principal quantum number) value tell about the shell to which the electro belong, Ex, If n=1 electron belongs to the first shell (K) around the nucleus

l (Azimuthal quantum number) tell about angular momentum, and shape of the orbitals, and it designates the subshells to which the electron belongs to. For a given value of **'n', 'l'** can have a value ranging from 0 to n-1. Ex, If **n**=2 then, the value of **'l'** will be 0 and 1 (0 to n-1).

m_l (Magnetic orbital quantum number) determines the number of preferred orientations of the orbitals in the subshell, which are defined by given 'l' value.

Ex if 'l'= 2 then m_l = 2l+1 =2*2 +1= 5 m value ie., m=+2,+1,0,-2,-1.

26.

(b) 2s, 4d and 3p respectively

Explanation: Nuclear charge is defined as the net positive charge experienced by an electron in the orbital of a multi-electron atom. The closer the orbital, the greater is the nuclear charge experienced by the electron (s) in it.

(i) 2s is closer to the nucleus than 3s.Hence 2s will experience larger effective nuclear charge.

(ii) 4d will experience greater nuclear charge than 4f since 4d is closer to the nucleus than 4f.

(iii) 3p will experience greater nuclear charge since it is closer to the nucleus than 3f because 3p is closer to nucleus than 3f.

27.

(c) several series of lines named after their discoverers

Explanation: The emission spectrum of hydrogen consists of several series of sharp emission lines in the ultraviolet (Lyman series). in the visible (Balmer series), and in the infrared (Paschen series, Brackett series, etc,) regions of the spectrum. These series are named after their discoverer.

28.

(b) probability density of finding an electron

Explanation: Probability density of finding an electron at a point within an atom, it is possible to predict the region around the nucleus where the electron can most probably be found.

ψ^2 has no physical significance while ψ^2 represents the probability density of finding an electron.

29.

(c) Option (iii)

Explanation: In Schrodinger equation, $\hat{H}$ is a mathematical operator called Hamiltonian. It was introduced by Schrodinger from the expression for the total energy of the system.

30.

(b) Positive charge of the atoms very little space

Explanation: Positive charge of the atoms very little space

31. **(a)** Group Number

Explanation: Group Number

32.

(d) non-metals

Explanation: non-metals

33.

(c) Principal quantum number, Azimuthal quantum number or orbital angular momentum, and Magnetic orbital quantum number.

Explanation: Quantum numbers designate specific shells, subshells, orbitals, and spins of electrons.

There are a total of four quantum numbers:

i. The principal quantum number (n), describes the energy of an electron and the most probable distance of the electron from the nucleus. In other words, it refers to the size of the orbital and the energy level an electron is placed in.

ii. The orbital angular momentum quantum number (l), describes the shape of the orbital. It can also be used to determine the number of angular nodes.
iii. The magnetic quantum number (m), describes the energy levels in a subshell.
iv. The electron spin quantum number (ms) refers to the spin on the electron, which can either be up or down.

34.

(c) Stark effect

Explanation: Stark effect

35.

(d) 4f

Explanation: Here n= principal quantum number, l= azimuthal quantum number. For n = 4 and l = 3 The orbital is 4f (can have a maximum of 14 electrons).

36.

(c) Heisenberg's uncertainty principle

Explanation: Werner Heisenberg, a German physicist in 1927, stated the uncertainty principle which is the consequence of the dual behavior of matter and radiation. It states that it is impossible to determine simultaneously, the exact position and exact momentum (or velocity) of an electron. It rules out the existence of definite paths or trajectories of electron and other similar particles.

37.

(c) the associated uncertainties are hardly of any real consequence

Explanation: The effect of the Heisenberg uncertainty principle is significant only for motion of microscopic objects, it is negligible in case of macroscopic objects. For example, we apply the concept of uncertainty to an object of mass 1 milligram.

$\Delta x \times \Delta v_x = \frac{h}{4\pi m}$

$= \frac{6.626 \times 10^{-34}}{4 \times 3.1416 \times 10^{-6}} \approx 10^{-28} m^2 s^{-1}$

The value of $\Delta x \Delta v_x$ is very small and insignificant in this case. Therefore, when we deal with heavier objects the associated uncertainties have no real consequences and can be neglected.

38.

(b) 8.72×10^{-18} J $atom^{-1}$

Explanation: He^+ ion is a single electron species which resembles like hydrogen. Therefore, the energies of the stationary states of hydrogen-like ions are given by the expression

$E_n = 2.18 \times 10^{-18} \times \frac{Z^2}{n^2}$

Here n = 1 and Z = 2

$E_n = 2.18 \times 10^{-18} \times \frac{2^2}{1^2}$ = 8.72×10^{-18} J $atom^{-1}$

39.

(b) 21

Explanation: In the formation of a cation with 3^+ charges, the atom loses 3 electrons.

The no. of electrons in the atom will be 18 + 3 = 21.

In a neutral atom, the no. of protons is equal to the no. of electrons. So atomic no. is 21.

40.

(d) the splitting of emission lines in a Vacuum

Explanation: spin quantum number with two spin states of the electron represented by two arrows, ↑ (spin up) and ↓ (spin down) was introduced to account for the splitting of emission lines in a magnetic field.

41.

(b) probability density of finding an electron

Explanation: The probability density of finding an electron at a point within an atom, predicts the region around the nucleus where the electron can most probably be found.

42.

(b) $\alpha < \text{p} < \text{e}$

Explanation: α-particle (He^{2+}) has a very high mass compared to proton and electron, therefore a very small $\frac{e}{m}$ ratio. Proton and electron have the same charge (magnitude) but former is heavier, hence has a smaller value of $\frac{e}{m}$.

43. **(a)** electric and magnetic fields

Explanation: When an electric field is applied to a stream of cathode rays, they get deflected towards the positive plate. On the application of a magnetic field perpendicular to the path of the cathode rays, they get deflected in the direction expected of negative particles.

44.

(c) Photoelectric effect

Explanation: Electrons are ejected from the metal when the light of a certain frequency strikes the surface of a metal, This phenomenon is known as the photoelectric effect and the ejected electrons are called photoelectrons.

45. **(a)** Electrons move in a circular path of fixed energy called orbits.

Explanation: The Rutherford model cannot explain the stability of an atom. As if the electrons were stationary. electrostatic attraction between them will pull the electron towards the nucleus. It says nothing about the electronic structure of atoms. It can't explain how the electrons are distributed around the nucleus and what are energies of these electrons.

46.

(d) +3.4 eV

Explanation: Total energy of the electron, E = −3.4 eV

Kinetic energy of the electron is equal to the negative of the total energy.

K = −E = − (− 3.4) = +3.4 eV

Hence, the kinetic energy of the electron in the given state is +3.4 eV.

47.

(d) energy of quantum

Explanation: Max Planck theorized that energy was transferred in chunks known as quanta, equal to $h\nu$. The variable h is a constant equal to 6.63 $\times$ 10^{-34} J·s and the variable νrepresents the frequency in 1/s.

This equation allows us to calculate the energy of photons, given their frequency.

If the wavelength is given, the energy can be determined by first using the wave equation $(c = \lambda \times \nu)$ to find the frequency, then using Planck's equation to calculate energy.

48.

(d) behave like particles

Explanation: The photoelectric effect is the emission of electrons when light is shown into a material. Here the light behaves like a stream of particles (photons).

49.

(b) Hund's rule of maximum multiplicity

Explanation: Pairing of electrons in the orbitals belonging to the same subshell (p, d or f) does not take place until each orbital belonging to that subshell has got one electron each, i.e. it is singly occupied. This is called Hund's rule of maximum multiplicity.

50.

(c) 1.72 $\times$ 10^6 m^{-1}

Explanation: Wavenumber is defined as the reciprocal of a wavelength.

$\bar{\nu} = \frac{1}{\lambda}$

where, λ = wavelength = 5800 Å = 5.8 $\times$ 10^{-7} m

So, $\bar{\nu} = \frac{1}{5.8 \times 10^{-7}} =$ 1.72 $\times$ 10^6 m^{-1}.

51.

(d) $\Delta\mathrm{E} = h\nu$

Explanation: In his model of the atom, Bohr used Planck's quantum hypothesis, and of course his knowledge from prior findings. Bohr uses Ryberg's formula for explaining how the electrons emit light as they move from one orbital to another. The point Bohr was trying to get across is that energy is not continuous in an atom. We can say that an atom that is in the lowest energy level is in the ground state, and when it moves to a higher level it is in an excited state. The energy of a photon, lost or gained, is calculated using Planck's equation: (h is Planck's constant, 6.62607 $\times$ 10^{-34} J s / cycles, and v stands for frequency in cycles/s)

Energy Difference(ΔE) = $h\nu$

52.

(d) calcium

Explanation: calcium

53. **(a)** 4f

Explanation: For n = 4 the possible values of l are 0,1, 2, 3. The orbital with l = 3 is f orbital.

54.

(c) visible light

Explanation: Electromagnetic radiation in this range of wavelengths is called visible light or simply light. A typical human eye will respond to wavelengths from about 390 to 700 nm. In terms of frequency, this corresponds to a band in the vicinity of 430–770 THz.

55. **(a)** 1.3225 nm

Explanation: Radius of Bohr's n^{th} orbit for hydrogen atom is given by:

r_n = (0.0529 nm) n^2

For, n = 5

r_5 = (0.0529 nm) 5^2 = 1.3225 nm

56.

(b) at very low pressure and high voltage

Explanation: Production of cathode rays: Cathode rays are produced in the discharge tube (by low pressure and high temperature) by applying the following conditions:

- A high potential difference (>1200 V) is applied across the two aluminium electrodes.
- The length of the tube is 30 cm and the diameter is 3 cm.
- The pressure inside the tube is maintained below 0.01 mm of Hg.

57.

(c) Lyman series

Explanation: The Lyman series is a hydrogen spectral series of transitions and resulting ultraviolet emission lines of the hydrogen atom as an electron goes from n $\geq$ 2 to n = 1 (where n is the principal quantum number), the lowest energy level of the electron.

58. **(a)** 1

Explanation: Explanation: For p orbital, n = 3 and l = 1

No. of radial nodes = n - l - 1

No. of radial nodes for 3p orbital = 3 - 1 - 1 = 1

59.

(c) ${}^{35}_{17}Cl$

Explanation: Chlorine has atomic number 17 and atomic mass 35.5u.

60.

(c) 6.626 $\times$ 10^{-34} m

Explanation: Mass of ball = 0.1 kg

Velocity of ball = 10 m/s

According to de Broglie equation

Wave length =$\frac{h}{mv} = \frac{6.626\times10^{-34}}{0.1\times10}$ = 6.626 $\times$ 10^{-34} m.

61.

(b) equal to or greater than h/4π.

Explanation: The uncertainty principle says that we cannot measure the position (x) and the momentum (p) of a particle with absolute precision. The more accurately we know one of these values, the less accurately we know the other. Multiplying together the errors in the measurements of these values has to give a number greater than or equal to half of a constant called "h-bar". This is equal to Planck's constant (usually written as h) divided by 2π.

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

62.

(d) 1.988×10^{-18} J

Explanation: We know Planck's equation is

E = hv

where E is energy, h is Planck’s constant and v is frequency.

E = $6.626 \times 10^{-34} \times 3 \times 10^{15} = 1.988 \times 10^{-18}$ J

63.

(d) (A)-(q), (B)-(s), (C)-(p), (D)-(r)

Explanation: (A)-(q), (B)-(s), (C)-(p), (D)-(r)

64.

(c) Kr (atomic no.=36)

Explanation: The first inert gas which contains d electrons is krypton. Its atomic number is 36 and its electronic configuration is

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

Total number of s electrons = 8 Total number of p electrons = 6 + 6 + 6 = 18 Total number of d electrons = 10 .

Differencein total number of p and s electrons = 18-8= 10

Thus, the inert gas is krypton.

65.

(c) motions of the microscopic objects that have both observable wave-like and particle-like properties

Explanation: Quantum mechanics, science dealing with the behaviour of matter and light on the atomic and subatomic scale. It attempts to describe and account for the properties of molecules and atoms and their constituents—electrons, protons, neutrons, and other more esoteric particles such as quarks and gluons.

66.

(c) Group Number

Explanation: Group Number

67.

(d) 1

Explanation: Number of radial nodes = n−l−1

where n = principal quantum number, l = azimuthal quantum number

For 3p orbital, n=3 and l=1

∴ The number of radial nodes for 3p orbital =3−1−1=3−2=1.

68.

(d) $3d^5 4s^2$

Explanation: $3d^5 4s^2$

The 3d orbital in this case is exactly half-filled and the 4s orbital is completely filled. The half filled and completely filled electronic configurations have a symmetrical distribution of electrons which leads to stability. The 4s sub-energy level is at lower energy than the 3d sub-energy level.

69. **(a)** 0.40 nm

Explanation: $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{1.67\times10^{-27}\times1\times10^3}$

= 3.97×10^{-10} m $\approx$ 0.40 nm

70.

(d) Visible region

Explanation: The spectral lines obtained as a result of transition of electrons from higher energy levels to the second energy level of a hydrogen atom give rise to Balmer Series which is in the visible region of electromagnetic spectrum.

71.

(b) Atomic number

Explanation: The number of electrons in an atom is equal to its atomic number i.e. number of protons.

72.

(c) Option (iii)

Explanation: Dual character of the electromagnetic radiation and experimental results regarding atomic spectra which can be explained only by assuming quantised electronic energy levels in atoms.

73.

(c) R.A. Millikan's oil drop experiment

Explanation: In 1909, Robert Millikan and Harvey Fletcher conducted the oil drop experiment to determine the charge of an electron. They suspended tiny charged droplets of oil between two metal electrodes by balancing downward gravitational force with upward drag and electric forces.

The experiment helped earn Millikan a Nobel prize in 1923

74.

(c) their increasing energies

Explanation: The Aufbau Principle states that in the ground state of an atom, an electron enters the orbital with the lowest energy first and subsequent electrons are fed in the order of increasing energies. The word 'aufbau' in German means 'building up'. Here, it refers to the filling up of orbitals with electrons.

75.

(b) absorbing selected wavelengths from an input of continuous spectrum

Explanation: In an absorption spectrum, portions of a continuous spectrum (light containing all wavelengths) are missing because they have been absorbed by the medium through which the light has passed; the missing wavelengths appear as dark lines or gaps. Black lines indicating where no light gets through to the element.