# KD EDUCATION ACADEMY [9582701166]

Time : 6 Hour | STD 11 Science Chemistry | Total Marks : 230

kd 90+ Questions ch- 2 ch-2 structure of atom

*** Choose The Right Answer From The Given Options.[1 Marks Each] [48]**

1. The angular moment of electron in d-orbital is equal to:
   ( Where $\hbar = \frac{h}{2\pi}$)

(A) $2\sqrt{3}\ \hbar$ (B) $0\ \hbar$ (C) $\sqrt{6}\ \hbar$ (D) $\sqrt{2}\hbar$

**Ans. :**

c. $\sqrt{6}\ \hbar$

**Explanation:**

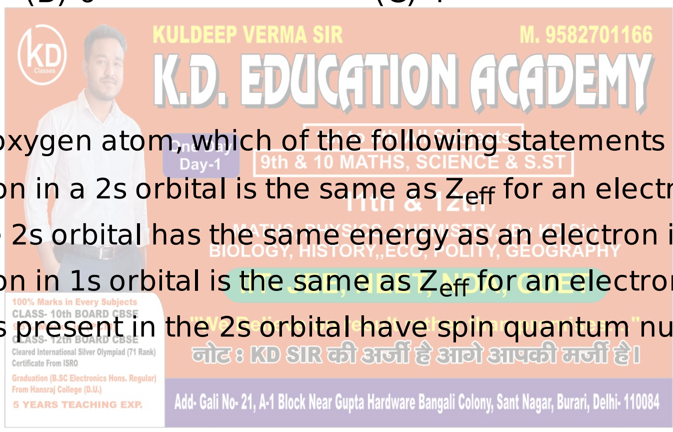
$$m, vr = l\sqrt{(l+1)}\frac{h}{2\pi} = \sqrt{2 \times 3}\frac{h}{2\pi}$$
$$= \sqrt{6}\frac{h}{2\pi} = \sqrt{6}\hbar$$

2. Number of electrons surroundings Kr in $KrF_2$ is:

(A) 10 (B) 6 (C) 4 (D) 8

**Ans. :**

a. 10




3. For the electrons of oxygen atom, which of the following statements is correct?

(A) Zeff for an electron in a 2s orbital is the same as $Z_{eff}$ for an electron in a 2p orbital.

(B) An electron in the 2s orbital has the same energy as an electron in the 2p orbital.

(C) Zeff for an electron in 1s orbital is the same as $Z_{eff}$ for an electron in a 2s orbital LED.

(D) The two electrons present in the 2s orbital have spin quantum numbers m, but of opposite sign.

**Ans. :**

d. The two electrons present in the 2s orbital have spin quantum numbers m, but of opposite sign.

**Explanation:**

i. Electrons in 2s and 2p orbitals have different screen effect. Hence, their $Z_{eff}$ are different. $Z_{eff}$ of 2s orbital > $Z_{eff}$ of 2p orbital,
   Therefore, it is not correct.

ii. Energy of 2s orbital < energy of 2p orbital.
   Hence, it is not correct.

iii. $Z_{eff}$ of 1s orbital $\neq Z_{eff}$ of 2s orbital,
   Hence, it is incorrect.

iv. For the two electrons of 2s orbital, the value of $m_s$ is $+\frac{1}{2}$ and $-\frac{1}{2}$.
   Hence, it is correct.

4. Isotopes have same____but different____.

(A) Atomic number, mass number. (B) Mass number, atomic number.

(C) Number of neutrons, atomic number. (D) None of these.

**Ans. :**

a. Atomic number, mass number.

**Explanation:**

Isotopes of an element have same atomic number and different mass numbers.

5. For an atom of a given element, the number of electrons equals to:

(A) The number of protons + number of neutrons.

(B) The atomic number of the element.

(C) The number of proton − number of neutrons.

(D) The mass number of the element.

**Ans. :**

b. The atomic number of the element.

**Explanation:**

For an atom of a given element, the number of electrons are equal to the number of protons which is equal to atomic number of the element.

6. The Bohr model of atoms:

(A) Uses Einstein's photo electric equation.

(B) Predicts continuous emission spectra for atoms.

(C) Predicts the same emission spectra for all types of atoms.

(D) Assumes that the angular momentum of electrons is quantized.

**Ans. :**

d. Assumes that the angular momentum of electrons is quantized.

**Explanation:**

Bohr model of an atom states that only those orbits are allowed where angular momentum of electron are integral multiple of nh/2π. These orbits have quantized energy and angular momentum associated with electron.The model can be applied to hydrogen or hydrogen-like atoms to explain their line emission spectrum.



7. Which of the following statements is/ are correct regarding Rutherford scattering experiment?

(A) Most of the A-particles passed through the gold foil remain undeflected.

(B) A small fraction of the Q-particles was deflected by small angles.

(C) A very few a-particles $(\sim 1$ in $20000)$ bounced back, i.e. were deflected by nearly 180°.

(D) All of the above.

**Ans. :**

d. All of the above.

8. The band spectrum is caused by:

(A) Molecules.

(B) Atoms.

(C) Any substance in solid state.

(D) Any substance in liquid state.

**Ans. :**

a. Molecules.

**Explanation:**

The band spectrum is caused by molecules. The energy levels of molecules are so close to each other that they combine to form a band. The valence band and conduction band are two types of bands. Electron transition between these two bands forms band spectrum.

For example a spectrum of air. The bright bands are due to molecular oxygen ($O_2$), molecular nitrogen ($N_2$), and other molecules.

9. The first use of quantum theory to explain the structure of atom was made by:

(A) Heisenberg (B) Bohr (C) Planck (D) Einstein

**Ans. :**

b. Bohr

**Explanation:**

It was in 1913 that Neils Bohr put forth the stability of the atom and with the help of Planck's quantum theory explain the reason for spectral lines. Bohr first made use of quantum theory to explain the structure of atoms and proposed that the energy of electrons in an atom is quantized.

10. The ionisation enthalpy of hydrogen atom is $1.312 \times 10^6 \text{J mol}^{-1}$. The energy required to excite the electron in the atoms from n = 1 to $n_2$ = 2 is:

(A) $6.56 \times 10^5 \text{J mol}^{-1}$ (B) $9.84 \times 10^5 \text{J mol}^{-1}$

(C) $7.56 \times 10^5 \text{J mol}^{-1}$ (D) $8.51 \times 10^5 \text{J mol}^{-1}$

**Ans. :**

b. $9.84 \times 10^5 \text{J mol}^{-1}$

**Explanation:**

$$\Delta \mathrm{E} - \mathrm{E}_2 - \mathrm{E}_1$$

$$= \left(\frac{-1.312 \times 10^6}{2^2}\right) - \left(\frac{-1.312 \times 10^6}{1}\right)$$

$$= 9.84 \times 10^5 \mathrm{~J~mol}^{-1}$$

11. The atomic number of an element is determined by:

(A) The number of electrons in one atom. (B) The number of neutrons in one atom.

(C) The valency of the element. (D) The number of protons in one atom.

**Ans. :**

d. The number of protons in one atom.

**Explanation:**

Atomic number is the number of protons in the nucleus of an atom and also the total positive charge in the atomic nucleus.

12. For the electrons of oxygen atom, which of the following statements is correct?

(A) $Z_{eff}$ for an electron in a 2s orbital is the same as $Z_{eff}$ for an electron in a 2p orbital.

(B) An electron in the 2s orbital has the same energy as an electron in the 2p orbital.

(C) $Z_{eff}$ for an electron in 1s orbital is the same as $Z_{eff}$ for an electron in a 2s orbital.

(D) The two electrons present in the 2s orbital have spin quantum numbers $m_s$ but of opposite sign.

**Ans. :**

d. The two electrons present in the 2s orbital have spin quantum numbers $m_s$ but of opposite sign.

**Explanation:**

a. Electrons in 2s and 2p orbitals have different screening effect. Hence, their $Z_{eff}$ is different. $Z_{eff}$ of 2s orbital > $Z_{eff}$ of 2p orbital.

Therefore, it is not correct.

b. Energy of 2s orbital < energy of 2p orbital.

Hence, it is not correct.

c. $Z_{eff}$ of 1s orbital $\neq$ $Z_{eff}$ of 2s orbital

Hence, it is incorrect.

d. For the two electrons of 2s orbital, the value of $m_s$ is $+\frac{1}{2}$ and $-\frac{1}{2}$.

Hence, it is correct.

13. An atom of an element has two electrons in the M shell. Identify its atomic number.

(A) 10 (B) 12 (C) 14 (D) 15

**Ans. :**

b. 12

**Explanation:**

For M shell value of n = 3. Thus the electronic configuration is: 2, 8, 2 and atomic number is 12.

14. Atomic mass unit is abbreviated as _________.

(A) atm (B) ama (C) a.m.u (D) aum

**Ans. :**

c. a.m.u

**Explanation:**

Atomic mass unit is abbreviated as a.m.u.



15. Who suggested the distribution of electrons into different orbits of an atom?

(A) E. Goldstein (B) Ernest Rutherford

(C) Bohr and Bury (D) Dalton

**Ans. :**

c. Bohr and Bury

**Explanation:**

The arrangement and distribution of electrons in different orbits were given by Bohr and Bury. The arrangement of electrons in different shells and sub-shells is known as the electronic configuration of a particular element.

16. After completion of 'np' level, the electron enters into which level according to (n + p) rule?

(A) (n − 1)d (B) (n + 1)s (C) nd (D) (n + 1)p

**Ans. :**

b. (n + 1)s

**Explanation:**

Energy of nd level would be higher than (n + 1)s.

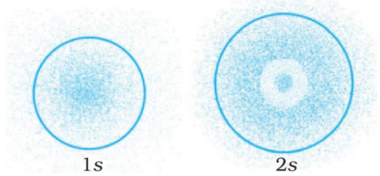
nd = n + 2, (n + 1)s = n + 1.

So, electron will enter into lower energy level.

i.e, (n + 1)s

Let us take an example of ′4p′ orbital. As per Moeller diagram, the orbital that will be filled after ′4p′ orbital is ′5s′.

17. The probability density plots of 1s and 2s orbitals are given in Fig.:




The density of dots in a region represents the probability density of finding electrons in the region.

On the basis of above diagram which of the following statements is incorrect?

(A) 1s and 2s orbitals are spherical in shape.

(B) The probability of finding the electron is maximum near the nucleus.

(C) The probability of finding the electron at a given distance is equal in all directions.

(D) The probability density of electrons for 2s orbital decreases uniformly as distance from the nucleus increases.

**Ans. :**

d. The probability density of electrons for 2s orbital decreases uniformly as distance from the nucleus increases.

**Explanation:**

The probability density of electrons for 2s orbital first increases then decreases and after that it begins to increase again.

18. Total number of orbitals associated with third shell will be ______.

(A) 2 (B) 4 (C) 9 (D) 3

**Ans. :**

c. 9

**Explanation:**

Total number of orbitals associated with $n^{th}$ shell

$= n^2$

Total number of orbitals associated with third shell

$= (3)^2 = 9$

19. Identify the correct order of increase in the energy of the orbitals for hydrogen atom:

(A) 1s < 28 = 2p < 3s = 3p = 3d < 4s = 4 p = 4d = 4f

(B) 1s > 2s = 2p > 3s = 3p = 3d > 4s = 4p = 4d = 4f

(C) 1s = 2s = 3s = 4s > 2p = 3 p = 4p > 3d = 4d > 4f

(D) 1s = 2s = 3s = 4s < 2p = 3p = 4p < 3d = 4d < 4f

**Ans. :**

a. 1s < 28 = 2p < 3s = 3p = 3d < 4s = 4 p = 4d = 4f

20. For an element, A = 34 and N = 19, What is the atomic number of the element?

(A) 34 (B) 19 (C) 53 (D) 15

**Ans. :**

d. 15

**Explanation:**

A is the mass number and N is the number of neutrons.

A = Z + N

Z = A − N

Z = 34 − 19

Z = 15

21. Impossible orbital among the following is:

(A) 3f (B) 2p (C) 4d (D) 2s

**Ans. :**

a. 3f

**Explanation:**

If the value of principle quantum number is 3. So the maximum possible value of Azimuthal quantum number is (3 - 1) = 2 which describes the d subshell. But for f subshell, the value of l must be 3. So, 3f orbital is not possible at all.

22. Which of the following has the same number of protons?

(A) Isobars (B) Isoelectronic

(C) Isotopes (D) Isotones

**Ans. :**

c. Isotopes

**Explanation:**

Isotopes are elements having the same atomic number but different mass numbers.

e.g: ${}_1H^1$, ${}_1H^2$, ${}_1H^3$ are isotopes of hydrogen.

23. Which of the following pairs of d-orbitals have electron density along the axis?

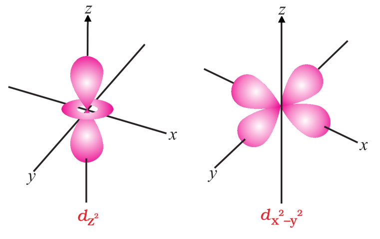
(A) $d_{z^2} d_{xz}$ (B) $d_{xz}, d_{yz}$ (C) $d_{z^2}, d_{x^2y^2}$ (D) $d_{zy}, d_{x^2y^2}$

**Ans. :**

c. $d_{z^2}, d_{x^2y^2}$

**Explanation:**

They have electron density along the axis.




24. The de Broglie wavelengths associated with a ball of mass 1kg having kinetic energy 0.5J is:

(A) $6.626 \times 10^{-34}$m (B) $13.20 \times 10^{-34}$m (C) $10.38 \times 10^{-21}$m (D) $6.626 \times 10^{-34}$A

**Ans. :**

a. $6.626 \times 10^{-34}$m

**Explanation:**

$\lambda = \frac{h}{mv}$ and K.E. $= \frac{1}{2}mv^2$

$v^2 = \frac{2KE}{m}$

$$\Rightarrow v = \sqrt{\frac{KE \times 2}{m}}$$

$$\lambda = \frac{h}{m\sqrt{\frac{2KE}{m}}}$$

$$= \frac{h}{\sqrt{2KE \times m}} = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 0.5 \times 1}}$$

$$= 6.626 \times 10^{-34} m$$

25. A neutral atom has 13 electrons and 14 neutrons. Its mass number is ____________.

(A) 13 (B) 26 (C) 27 (D) 28

**Ans. :**

c. 27

26. The atomic number of an element is 32 and mass number 55. Calculate the number of neutrons?

(A) 23 (B) 32 (C) 21 (D) 25

**Ans. :**

a. 23

**Explanation:**

Atomic number or number of protons = 32

Mass number = 55

Mass number (A) = Number of protons + Number of neutrons

55 = 32 + Number of neutrons

Number of neutrons = 55 − 32

Number of neutrons = 23

27. The electronic configuration of an element is $1s^2 2s^2 2p^3$. The number of unpaired electron in this atom are:

(A) 3 (B) 5 (C) 7 (D) 1

**Ans. :**

a. 3

28. The maximum number of electrons that can be filled into all the orbitals corresponding to the azimuthal quantum number l = 3, is:

(A) 14 (B) 15 (C) 12 (D) 18

**Ans. :**

a. 14

**Explanation:**

For l = 3, possible values of m = 2l + 1 = 7. For each m, there can be 2 electrons filled.

Maximum number of electrons, thus = 2 × 7 = 14.

29. Aufbau principle does not give the correct arrangement of filling up of the atomic orbitals in:

(A) Cu and Zn (B) Co and Zn (C) Mn and Cr (D) Cu and Cr

**Ans. :**

d. Cu and Cr

**Explanation:**

Aufbau principle does not give the correct arrangement of filling up of atomic orbitals in copper and chromium because half-filled and completely filled electronic configuration of Cr and Cu have lower energy and therefore, more stable.

Cr(Z = 24) = $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6\ 3d^5, 4s^1$

Cu(Z = 29) = $1s^2, 1s^2\ 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^1$

30. Which of the following options does not represent ground state electronic configuration of an atom?

(A) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$

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

(C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

(D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$

**Ans. :**

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

**Explanation:**

Correct configuration should be $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ for the copper which has atomic number 29(29Cu). Due to extra stability of full filled orbital of d-subshell, the last electron enter into d-orbital instead of s-orbital.

31. Magnetic moment 2.83BM is given by which of the following ions? [Atomic number Ti = 22, Cr = 24, Mn = 25, Ni = 28].

(A) $Ti^{3+}$ (B) $Ni^{2+}$ (C) $Cr^{2+}$ (D) $Mn^{2+}$

**Ans. :**

b. $Ni^{2+}$

**Explanation:**

$4s^0 3d^8$ has 3 unpaired electon,

$\mu = \sqrt{n(n+2)} = \sqrt{3 \times 5} = \sqrt{15}$

$= 3.83BM.$



32. In the line spectrum of hydrogen, the lines described by the formula

$\overline{v} = 109.677\left(\frac{1}{2^2} - \frac{1}{n^2}\right)cm^{-1}$ where, n = integer, $n \geq 3.$

Constitutes:

(A) Balmer series.

(B) Lyman series.

(C) Pfund series.

(D) Paschen series.

**Ans. :**

a. Balmer series.

33. The number of radial nodes for 3p orbital is __________.

(A) 3. (B) 4. (C) 2. (D) 1.

**Ans. :**

d. 1.

**Explanation:**

Number of radial nodes = n - 1 - 1

For 3p orbital, n = 3 - 1 - 1 = 1

Number of radial nodes = 3 - 1 - 1 = 1.

34. Pauli exclusion principle states that:

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

(B) Only two electrons may exist in the same orbital and these electrons must have opposite spin.

(C) Both (a) and (b).

(D) None of the above.

**Ans. :**

c. Both (a) and (b).

35. If $E_A$, $E_B$ and $E_C$ represent kinetic energies of an electron, alpha particle and proton respectively and each moving with same de-Broglie wavelength, then choose the correct increasing representation,

(A) $E_A = E_B = E_C$ (B) $E_A > E_B > E_C$ (C) $E_B > E_C > E_A$ (D) $E_A < E_C < E_B$

**Ans. :**

d. $E_A < E_C < E_B$

36. Identify the pairs which are **not** of isotopes?

(A) ${}^{13}_{6}X,\ {}^{13}_{6}Y.$ (B) ${}^{35}_{17}X,\ {}^{37}_{17}Y.$ (C) ${}^{14}_{6}X,\ {}^{14}_{7}Y.$ (D) ${}^{8}_{4}X,\ {}^{8}_{5}Y.$

**Ans. :**

c. ${}^{14}_{6}X,\ {}^{14}_{7}Y.$

d. ${}^{8}_{4}X,\ {}^{8}_{5}Y.$

**Explanation:**

Isotopes have the same atomic number but different mass number.

$\therefore \left({}^{14}_{6}X,\ {}^{14}_{7}Y\right)$ and $\left({}^{8}_{4}X,\ {}^{8}_{5}Y\right)$ are not isotopes.

37. The pair of ions having same electronic configuration is ______.

(A) $Cr^{3+}$, $Fe^{3+}$ (B) $Fe^{3+}$, $Mn^{2+}$ + (C) $Fe^{3+}$, $CO^{3+}$ (D) $Sc^{3+}$, $Cr^{3+}$

**Ans. :**

b. $Fe^{3+}$, $Mn^{2+}$ +

**Explanation:**

${}_{26}Fe$ = [Ae] $3d^6$, $4s^2$ ${}_{26}Fe^{3+}$ = [Ar] $3d^5$

${}_{25}Mn$ = [Ar] $3d^5$, $4s^2$ ${}_{25}Mn^{2+}$ = [Ar] $3d_5$

38. A ray of white light is spread out into a series of coloured bands of visible light are called:

(A) Visible band. (B) Spectrum.

(C) Electronic spectrum. (D) None of these.

**Ans. :**

b. Spectrum.

39. How will you find out the maximum number of electrons in the main energy level?

(A) n (B) $n^2$ (C) $2n^4$ (D) $2n^2$

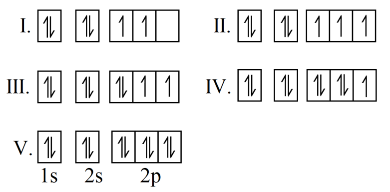
**Ans. :**

d. $2n^2$

**Explanation:**

The maximum number of electrons in an energy level is given by $2(n^2)$.

40. Electronic configuration of five elements I, II, III, IV, V is mentioned below.




In the above configuration element I, II, III, IV and V represent as:

(A) C, N, O, F, Ne
(B) Ne, F, O, N, C
(C) C, O, N, Ne, F
(D) O, C, F, Ne, V

**Ans. :**

a. C, N, O, F, Ne

41. Atomic number of an atom is equal to the __________.

(A) Number of protons.
(B) Number of electrons.
(C) Both a and b.
(D) Sum of proton and electron.

**Ans. :**

c. Both a and b.

**Explanation:**

Atomic number (Z) is the number of protons in an atom. It is also equal to the number of electrons in the atom.

Atomic number = number of protons

Example: the atomic number of an element is 12, then, its atom contains 12 protons and 12 electrons.

42. What tool was Thomson using when he discovered the electron?

(A) Magnifying Glass
(B) Hammer
(C) Cathode Ray
(D) Microscope

**Ans. :**

c. Cathode Ray

43. Thomson showed that the stream of particles in cathode ray tube is made up of small particles which are a component of the atom and is:

(A) Neutral.
(B) Negatively charged.
(C) Positively charged.
(D) Both A and B.

**Ans. :**

b. Negatively charged.

**Explanation:**

Thomson discovered electrons using the cathode ray tube. It has been previously seen that if a electric current is passed through a vacuum tube, a glowing stream is formed. Thomson found that the mysterious glowing stream would bend toward a positively charged electric plate. He concluded that the stream is negatively charged. He also concluded based on his experiments that the negative stream has negatively charged particles that he called corpuscles (later renamed electrons).

44. Protons and neutrons are also called __________.

(A) Nucleons
(B) Isotope
(C) Isobars
(D) Elements

**Ans. :**

a. Nucleons

**Explanation:**

Protons and neutrons are also called nucleons.

45. Total number of orbitals associated with third shell will be _________.

(A) 2. (B) 4. (C) 9. (D) 3.

**Ans. :**

c. 9.

**Explanation:**

No of orbitals in 3$^{rd}$ shell (n = 3) = $n^2 = 3^2 = 9$.

46. Who was the first scientist to propose a model for the structure of an atom?

(A) J.J. Thomson (B) Dalton

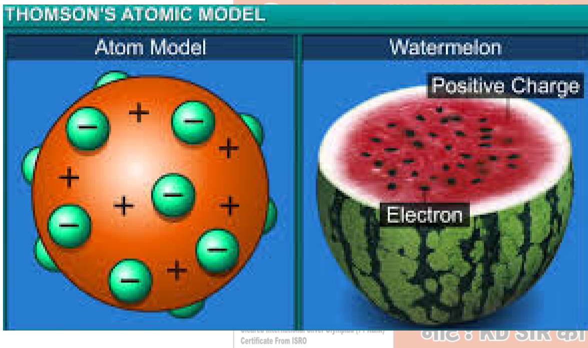
(C) Ernest Rutherford (D) E. Goldstein

**Ans. :**

a. J.J. Thomson

**Explanation:**

J.J. Thomson was the first one to propose a model for the structure of an atom.






47. Number of angular nodes for 4d orbital is_____.

(A) 4 (B) 3 (C) 2 (D) 1

**Ans. :**

c. 2

48. The mass number of a nucleus is:

(A) Always less than its atomic number.

(B) Always more than its atomic number.

(C) Sometimes equal to its atomic number.

(D) Sometimes equal and sometimes more than its atomic number.

**Ans. :**

c. Sometimes equal to its atomic number.

*** a statement of Assertion (A) is followed by a statement of Reason (R). [2]**
**Choose the correct option.**

49. **Note:** In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

**Assertion (A):** Black body is an ideal body that emits and absorbs radiations of all frequencies.

**Reason (R):** The frequency of radiation emitted by a body goes from a lower frequency to higher frequency with an increase in temperature.

a. Both A and R are true and R is the correct explanation of A.
b. Both A and R are true but R is not the explanation of A.
c. A is true and R is false.
d. Both A and R are false.

**Ans. :**

b. Both A and R are true but R is not the explanation of A.

**Explanation:**

The ideal body, which emits and absorbs radiations of all frequencies, is called a black body and the radiation emitted by such a body is called black body radiation. The exact frequency distribution of the emitted eadiation (i.e. intensity versus frequency curve of the radiation) from a black body depends only on its temperature. At a given temperature, intensity of radiation emitted increases with decrease of wavelength, reaches a maximum value at a given wavelength and then starts decreasing with further decrease of wavelength.

50. **Note:** In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

**Assertion (A):** It is impossible to determine the exact position and exact momentum of an electron simultaneously.

**Reason (R):** The path of an electron in an atom is clearly defined.

a. Both A and R are true and R is the correct explanation of A.
b. Both A and R are true and R is not the correct explanation of A.
c. A is true and R is false.
d. Both A and R are false.



**Ans. :**

c. A is true and R is false.

**Explanation:**

The effect of Heisenberg Uncertainty Principal is significant only for motion of microscopic objects and is negligible for that of macroscopic objects.

## * Answer The Following Questions In One Sentence.[1 Marks Each] [10]

51. Write the complete symbol for the atom with the given atomic number (Z) and atomic mass (A),

Z = 4 , A = 9.

**Ans. :** ${}^{9}_{4}\mathrm{Be}$

52. Write the complete symbol for the atom with the given atomic number (Z) and atomic mass (A),

Z = 17 , A = 35.

**Ans. :** ${}^{35}_{17}\mathrm{Cl}$

53. Among the following pairs of orbitals which orbital will experience the larger effective nuclear charge?

3d and 3p.

**Ans. :** 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.

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

54. Write electronic configuration of:

    i. $Na^{+}(11)$,

    ii. $Cl^{-}(17)$.

**Ans. :**

i. **$Na^{-}(11)$:** $1s^2\ 2s^2\ 2p^6$,

ii. **$Cl^{-}(17)$:** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$.

55. Write the values of the quantum number n, l, m and s for electron filling 21st place in the atom of element with atomic number 24.

**Ans. :** Electronic configuration of element,

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

21st electron goes to 3d-orbital. Its quantum numbers are,

$\mathrm{n} = 3, \mathrm{l} = 2, \mathrm{s} = +\frac{1}{2} \text{ or } -\frac{1}{2}$

m can have any value out of -2, -1, 0, +1, + 2.

56. Why is 4s-orbital filled before 3d-orbital?

**Ans. :** 4s-orbital has (n + l) = 4 + 0 = 4,

Which is lower than that of 3d, i.e. 3 + 2 = 5.

57. Why is energy of 1s electron lower than 2s electron?

**Ans. :** Is electron is closer to nucleus than 2s, therefore, has more force of attraction.

58. Why is following electronic configuration not correct for ground state of Cr atom? (Atomic number = 24) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^4$.

**Ans. :** The electronic configuration of Cr(24) in ground state is,

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$ because half-filled orbitals are more stable.

59. How are $d_{xy}$ and $d_{x^2} - y^2$ orbitals related?

**Ans. :** The $d_{xy}$ orbital is exactly like $d_{x^2} - y^2$ orbital except that its lobes are at an angle of 45° to the lobes of $d_{x^2} - y^2$ orbital.

60. How many radial and angular nodes are present in 2p-orbital.

**Ans. :** Radial node = n - l - 1 = 2 - 1 - 1 = 0,

Angular nodes = 'l' = 1

*** Given Section consists of questions of 2 marks each. [36]**

61. Which of the following orbitals are possible? 1p, 2s, 2p and 3f

**Ans. :** 1p is not possible because when n = 1, l = 0(for p, l = 1)

2s is possible because when n = 2, l = 0, 1(for s, l = 0)

2p is possible because when n = 2, l = 0, 1(for p, l = 1)

3f is not possible because when n = 3, l = 0, 1 , 2(for f, l = 3)

62. An atom of an element contains 29 electrons and 35 neutrons. Deduce

1. The number of protons
2. The electronic configuration of the element.

**Ans. :**

1. For an atom to be neutral, the number of protons is equal to the number of electrons.

   ∴ Number of protons in the atom of the given element = 29
2. The electronic configuration of the atom is

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

63. Indicate the number of unpaired electrons in:

Fe.

**Ans. :**

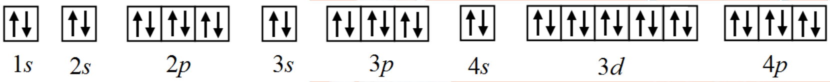
Krypton (Kr):

Atomic number = 36

The electronic configuration is:

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

The orbital picture of krypton is:




Since all orbitals are fully occupied, there are no unpaired electrons in krypton.



64. What are the atomic numbers of elements whose outermost electrons are represented by

a. $3s^1$

b. $2p^3$

c. $3p^5$?

**Ans. :**

a. **$3s^1$**

Completing the electron configuration of the element as

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

∴ Number of electrons present in the atom of the element

= 2 + 2 + 6 + 1 = 11

∴ Atomic number of the element = 11

b. **$2p^3$**

Completing the electron configuration of the element as

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

∴ Number of electrons present in the atom of the element = 2 + 2 + 3 = 7

∴ Atomic number of the element = 7

c. **$3p^5$**

Completing the electron configuration of the element as

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5\ 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

∴ Number of electrons present in the atom of the element = 2 + 2 + 6+2+5 = 17

∴ Atomic number of the element = 17

65. An electron is in one of the 3d orbitals. Give the possible values of n, l and ml for this electron.

**Ans. :** For the 3d orbital:

Principal quantum number (n) = 3

Azimuthal quantum number (l) = 2

Magnetic quantum number ($m_l$) = -2, -1, 0, 1, 2

66. The energy associated with the first orbit in the hydrogen atom is $-2.18 \times 10^{-18}$J atom$^{-1}$. What is the energy associated with the fifth orbit?

**Ans. :** Energy associated with the fifth orbit of hydrogen atom is calculated as:

$$E_5 = \frac{-(2.18 \times 10^{-18})}{(5)^2} = \frac{-2.18 \times 10^{-18}}{25}$$

$E_5 = -8.72 \times 10^{-20}$J

67. The velocity associated with a proton moving in a potential difference of 1000V is 4.37 $\times 10^5$ms$^{-1}$. If the hockey ball of mass 0.1kg is moving with this velocity, calcualte the wavelength associated with this velocity.

**Ans. :** According to de Broglie's expression,

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

Substituting the values in the expression,

$$\lambda = \frac{6.626 \times 10^{-34} Js}{(0.1 kg)(4.37 \times 10^5 ms^{-1})}$$

$$\lambda = 1.516 \times 10^{-38} m$$



68. Indicate the number of unpaired electrons in:
Fe.

**Ans. :**

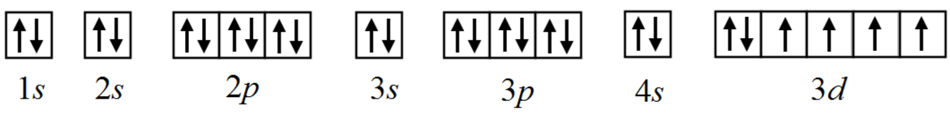
Iron (Fe):

Atomic number = 26

The electronic configuration is:

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

The orbital picture of chromium is:




From the orbital picture, iron has **four** unpaired electrons.

69. Which of the following orbitals are degenerate?
$3d_{xy}$, $4d_{xy}$, $3d_{z^2}$, $3d_{yz}$, $4d_{yz}$, $4d_{z^2}$

**Ans. :** Degenerate orbitals are the orbitals of the same sub shell of the same main shell. Hence, these are,

($3d_{xy}$, $3d_{z^2}$, $3d_{yz}$) and ($4d_{xy}$, $4d_{xz}$, $4d_{z^2}$).

70. In photoelectric effect experiment, irradiation of a metal with light of frequency $5 \times 10^{20}$ $s^{-1}$ yields electrons with maximum K.E. = $6.63 \times 10^{-14}$J. Calculate $v_0$(threshold frequency) for the metal.

**Ans. :** $hv = hv_0 + K.E$

$\Rightarrow h(v - v_0) = K.E$

$\Rightarrow v - v_0 = \frac{K.E}{h} = \frac{6.63\times10^{-14}J}{6.63\times10^{-34}Js}$

$= 1 \times 10^{20}s^{-1}$

$\Rightarrow 5 \times 10^{20} - 1 \times 10^{20}v_0$

$\Rightarrow v_0 = 4 \times 10^{20}s^{-1}$ or Hz

71. In an atom, an electron is moving with a speed of $600ms^{-1}$ with an accuracy of 0.005%. Find the certainty with which the position of the electron can be located. (h = $6.6 \times 10^{-34}kg/\ m^2s^{-1}$, mass of electron me = $9.1 \times 10^{-31}$kg).

**Ans. :** $\Delta v = 600 \times \frac{0.005}{100} = 0.03ms^{-1}$

Using Heisenberg's uncertainty principle,

you get, $\Delta x = \frac{6.6\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times0.03}$

$= 1.92 \times 10^{-3}m$

72. What will be the wavelength of a ball of mass 0.1kg moving with a velocity of $10ms^{-1}$?

**Ans. :** According to de-Broglie equation,

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

$= \frac{6.62\times10^{-34}kg/\ m^2s^{-1}}{0.1kg\times10ms^{-1}}$

$= 6.62 \times 10^{-34}m$

$'\lambda'$ is wavelength, 'h' is plancks constant, 'm' is mass of object, v is velocity.



73. Which orbital in each of the following pairs is lower in energy in a many electron atom?

i. 2s, 2p
ii. 3p, 3d
iii. 3s, 4s
iv. 40, 5f

**Ans. :**

i. 2s < 2p
ii. 3p < 3d
iii. 3s < 4s
iv. 4d < 5f

This is because lower the value of (n + 1), lower is the energy and if (n + l) are same, the orbital with lower value of n is of lower energy.

74. Nickel atom can lose two electrons to form $Ni^{2+}$ ion. The atomic number of nickel is 28. From which orbital will nickel lose two electrons.

**Ans. :** Nickel's atomic no. is 28 i.e $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$

It will lose 2 electrons from $4s^2$ (became $4s^0$) because s-orbital has highest energy level of n = 4 in this case. So s-orbital will lose first before, d-orbital and so $Ni^{+2}$ can be written as

[Ar] $4s^0\ 3d^8$.

75. Calculate the velocity of a particle of mass 0.1mg which is associated with a wavelength of $3.3 \times 10^{-29}$m ($h = 6.6 \times 10^{-34} kg/\ m^2 s^{-1}$).

**Ans. :** Given, $m = 0.1mg = 0.1 \times 10^{-6}kg$,

$\lambda = 3.3 \times 10^{-29}m$

$h = 6.6 \times 10^{-34}kg/\ m^2 s^{-1}$

de Broglie equation $= \lambda = \frac{h}{mc}$

$\Rightarrow c = \frac{h}{m}$

$= \frac{6.6 \times 10^{-34} kg/\ m^2 s^{-1}}{0.1 \times 10^{-6} kg \times 3.3 \times 10^{-29} m}$

$= 2 \times 10^2 ms^{-1}$

76. How many quantum numbers specify an:
    i. Electron,
    ii. Orbital? Name them.

**Ans. :**
  i. Four quantum numbers 'n', 'l', 'm' and 's' specify an electron.
  ii. Three quantum numbers, principal (n), azimuthal (l) and magnetic ($m_l$) specify an orbital.

77. A proton is moving with kinetic energy $5 \times 10^{-27}$J. What is the velocity of the proton?

**Ans. :** Mass of proton $= \frac{1.008 \times 10^{-3}}{6.02 \times 10^{23}} kg = 1.67 \times 10^{-27} kg$

$KE = \frac{1}{2}mv^2$

or $v = \frac{2KE}{m} = \frac{2 \times 5 \times 10^{-27}}{1.67 \times 10^{-27}} = 5.98$

78. Out of $Cu^{2+}$, $Fe^{2+}$ and $Cr^{3+}$, which ion is most paramagnetic and why?



**Ans. : Electronic configuration of:**

$Cu^{2+}$ = [Ar]$3d^9$

$Fe^{2+}$ = [Ar]$3d^6$

$Cr^{3+}$ = [Ar]$3d^3$

Paramagnetism depends on the number of unpaired electrons. From the electronic configuration of these ions, it is clear that $Cu^{2+}$ has one, $Fe^{2+}$ has four and $Cr^{3+}$ has three unpaired electrons. Therefore, $Fe^{2+}$ is most paramagnetic in nature.

*** Given Section consists of questions of 3 marks each. [51]**

79. Yellow light emitted from a sodium lamp has a wavelength $(\lambda)$ of 580 nm. Calculate the frequency (ν) and wavenumber $(\bar{v})$ of the yellow light.

**Ans. :** From the expression,

$\lambda = \frac{c}{v}$

We get,

$v = \frac{c}{\lambda} \ldots (1)$

Where,

ν = frequency of yellow light

c = velocity of light in vacuum = $3 \times 10^8$ m/s

λ = wavelength of yellow light = 580nm = $580 \times 10^{-9}$ m

Substituting the values in expression (i)

$$v = \frac{3\times10^8}{580\times10^{-9}} = 5.17 \times 10^{14}\ s^{-1}$$

Thus, frequency of yellow light emitted from the sodium lamp

= $5.17 \times 10^{14}\ s^{-1}$

Wave number of yellow light, $\bar{v} = \frac{1}{\lambda}$

$$= \frac{1}{580\times10^{-9}} = 1.72 \times 10^6\ m^{-1}$$

80. Write the electronic configurations of the following ions:

    a. $H^-$
    b. $Na^+$
    c. $O^{2-}$
    d. $F^-$

**Ans. :**

a. **$H^-$ ion**

The electronic configuration of H atom is $1s^1$.

A negative charge on the species indicates the gain of an electron by it.

∴ Electronic configuration of $H^-$ = $1s^2$

b. **$Na^+$ ion**

The electronic configuration of Na atom is $1s^2\ 2s^2\ 2p^6\ 3s^1$.

A positive charge on the species indicates the loss of an electron by it.

∴ Electronic configuration of $Na^+$ = $1s^2\ 2s^2\ 2p^6\ 3s^0$ or $1s^2\ 2s^2\ 2p^6$

c. **$O^{2-}$ ion**

The electronic configuration of 0 atom is $1s^2\ 2s^2\ 2p^4$.

A dinegative charge on the species indicates that two electrons are gained by it.

∴ Electronic configuration of $O^{2-}$ ion = $1s^2\ 2s^2\ p^6$

d. **$F^-$ ion**

The electronic configuration of F atom is $1s^2\ 2s^2\ 2p^5$.

A negative charge on the species indicates the gain of an electron by it.

∴ Electron configuration of $F^-$ ion = $1s^2\ 2s^2\ 2p^6$

81. Lifetimes of the molecules in the excited states are often measured by using pulsed radiation source of duration nearly in the nano second range. If the radiation source has the duration of 2 ns and the number of photons emitted during the pulse source is $2.5 \times 10^{15}$, calculate the energy of the source.

**Ans. :** Frequency of radiation (ν),

$$v = \frac{1}{2.0\times10^{-9}s}$$

ν = $5.0 \times 10^8\ s^{-1}$

Energy (E) of source = Nhν

Where,

N = number of photons emitted

h = Planck's constant

ν = frequency of radiation

Substituting the values in the given expression of (E):

E = $(2.5 \times 10^{15})(6.626 \times 10^{-34} Js)(5.0 \times 10^{8} s^{-1})$

E = $8.282 \times 10^{-10} J$

Hence, the energy of the source (E) is $8.282 \times 10^{-10} J$.

82. An element with mass number 81 contains 31.7% more neutrons as compared to protons. Assign the atomic symbol.

**Ans. :** Let the number of protons in the element be x.

∴ Number of neutrons in the element

= x + 31.7% of x

= x + 0.317 x

= 1.317 x

According to the question,

Mass number of the element = 81

∴ (Number of protons + number of neutrons) = 81

$\Rightarrow \mathrm{x} + 1.317\mathrm{x} = 81$

$2.317\mathrm{x} = 81$

$\mathrm{x} = \frac{81}{2.317}$

$= 34.95$

$\therefore \mathrm{x} = 35$

Hence, the number of protons in the element i.e., x is 35.

Since the atomic number of an atom is defined as the number of protons present in its nucleus, the atomic number of the given element is 35.

∴ The atomic symbol of the element is $^{81}_{35}\mathrm{Br}$.



83. How many neutrons and protons are there in the following nuclei?

$^{13}_{06}\mathrm{C},\ ^{16}_{08}\mathrm{O},\ ^{24}_{12}\mathrm{Mg},\ ^{56}_{26}\mathrm{Fe},\ ^{88}_{38}\mathrm{Sr}$

**Ans. :** $^{13}_{06}\mathrm{C}$ :

Atomic mass = 13

Atomic number = Number of protons = 6

Number of neutrons = (Atomic mass) – (Atomic number)

= 13 – 6 = 7

$^{16}_{08}\mathrm{O}$ :

Atomic mass = 16

Atomic number = 8

Number of protons = 8

Number of neutrons = (Atomic mass) – (Atomic number)

= 16 – 8 = 8

$^{24}_{12}\mathrm{Mg}$ :

Atomic mass = 24

Atomic number = Number of protons = 12

Number of neutrons = (Atomic mass) – (Atomic number)

= 24 – 12 = 12

$^{56}_{26}\mathrm{Fe}$ :

Atomic mass = 56

Atomic number = Number of protons = 26

Number of neutrons = (Atomic mass) – (Atomic number)

= 56 – 26 = 30

$^{88}_{38}\mathrm{Sr}$ :

Atomic mass = 88

Atomic number = Number of protons = 38

Number of neutrons = (Atomic mass) – (Atomic number)

= 88 – 38 = 50

84. Correct the following electronic configuration of the elements in the ground state.

i. $1s^2\ 2s^1, 2p_x^2, 2p_y^2, 2p_z^2, 3s62, 2p_x^1$

ii. $1s^2\ 2s^1, 2p_x^1, 2p_y^1, 2p_z^1$

iii. $1s^2\ 2s^1, 2p^6, 3s^2, 3p^6, 3d^5$

iv. $1s^2\ 2s^2, 2p^6, 3p^6, 3d^4, 4s^2$

**Ans. :**

i. $1s^2\ 2s^2, 2p_x^2, 2p_y^2, 2p_z^2, 3s^2$

ii. $1s^2\ 2s^2, 2p_x^1, 2p_y^1, 2p_y^1, 2p_z^1$

iii. $1s^2\ 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^2$

iv. $1s^2\ 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$



85. The first shell may contain up to 2 electrons, the second shell up to 8, the third shell up to 18, and the fourth shell up to 32. Explain this arrangement in terms of quantum numbers.

**Ans. :** For the fust shell $n = 1, l = 0, m_l = 0, m_s = +\frac{1}{2}$ and $-\frac{1}{2}$. It can have 2 electrons both with opposite spins.

i. For $n = 2$,

$l = 0, m_l = 0, m_s = +\frac{1}{2}, -\frac{1}{2}$,

$l = 1, m_l = 1, 0 + 1, m_s = +\frac{1}{2}, -\frac{1}{2}$.

Therefore, a total of 2 + 6 = 8 electrons are present.

ii. For $n = 3$, when

$l = 0, m_l = 0, m_s = +\frac{1}{2}, -\frac{1}{2}$

$l = 1, m_l = -1, 0 + 1, m_s = \frac{1}{2}, -\frac{1}{2}$

$l = 2, m_l = -2, -1, 0, +1, +2, , m_s$

$= +\frac{1}{2}, -\frac{1}{2}$

Therefore, a total of 2 + 6 + 10 = 18 electlons aie present.

iii. For $n = 4$, when

$l = 0, m_l = 0, m_s = +\frac{1}{2}, -\frac{1}{2}$

$l = 1, m_l = -1, 0 + 1, m_s = +\frac{1}{2}, -\frac{1}{2}$

$l = 3, m_l = -2, -1, 0 + 1, +2, m_s = +\frac{1}{2}, -\frac{1}{2}$

$l = 3, m_l = -3, -2, -1, 0, +1, +2, +3, m_s$

$= +\frac{1}{2}, -\frac{1}{2}$

Therefore, a total of 2 + 6 + 10 + 14 = 32 electrons are present.

86. i. Define Aufbau's principle.

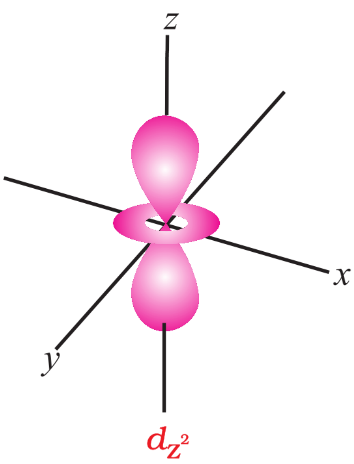
ii. Draw the shape of $d_{z^2}$ orbital.

iii. Which quantum number specify number of orbitals in a given subshell?

**Ans. :**

i. **Aufbau's principle:** Electrons are filled in the orbitals in increasing order of energies in grand state.

ii.






iii. Number of orbitals in gives subshell is decided by magnetic quantum number.

87. According to de Broglie, matter should exhibit dual behaviour, that is both particle and wave like properties. However, a cricket ball of mass 100g does not move like a wave when it is thrown by a bowler at a speed of 100km/h. Calculate the wavelength of the ball and explain why it does not show wave nature.

**Ans. :** $\lambda = \frac{h}{mv}$

$m = 100g = 0.1kg.$

$v = 100km/hr = \frac{100 \times 1000m}{60 \times 60s} = \frac{1000}{36} ms^{-1}$

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

$\lambda = \frac{6.626 \times 10^{-34} Js}{0.1kg \times \frac{1000}{36} ms^{-1}} = 6.626 \times 10^{-36} \times 36 m^{-1}$

$= 238.5 \times 10^{-36} m^{-1}$

88. Hydrogen atom has only one electron, so mutual repulsion between electrons is absent. However, in multielectron atoms mutual repulsion between the electrons is significant. How does this affect the energy of an electron in the orbitals of the same principal quantum number in multielectron atoms?

**Ans. :** The energy of an electron in a hydrogen atom is determined solely by the principal quantum number. Thus, the energy of the orbitals increases as follows:

1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f < (2.23),

The energy of an electron in a multielectron atom, that of the hydrogen atom, depends not only on its principal quantum number (shell), but also on its azimuthal quantum number (subshell). That is, for a given principal quantum number, s, p, d, f .... all have different energies.

89.
i. The mass of an electron is $9.1 \times 10^{-28}$g. If its K.E. is $3.0 \times 10^{-25}$J, calculate its wave-length in Angstrom. [h = $6.6 \times 10^{-34}$Js]
ii. What is photoelectric effect?

**Ans. :**

i. $\mathrm{m} = 9.1 \times 10^{-28}\mathrm{g} = 9.1 \times 10^{-31}\mathrm{kg}$

$\mathrm{K.E} = 3.0 \times 10^{-25}\mathrm{J}$

$\frac{1}{2}\mathrm{mv}^2 = 3.0 \times 10^{-25}\mathrm{J}$

$\mathrm{K.E} = \frac{1}{2}\mathrm{mv}^2$

$\Rightarrow \mathrm{V} = \sqrt{\frac{2\mathrm{KE}}{\mathrm{m}}}$

$\lambda = \frac{\mathrm{h}}{\mathrm{mV}} = \frac{\mathrm{h}}{\mathrm{m} \times \sqrt{\frac{2\mathrm{K.E}}{\mathrm{m}}}} = \frac{\mathrm{h}}{\sqrt{2 \times \mathrm{K.E} \times \mathrm{m}}}$

$\lambda = \frac{\mathrm{h}}{\sqrt{2\mathrm{m} \times \mathrm{K.E}}} = \frac{6.6 \times 10^{-34}\mathrm{Js}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 3 \times 10^{-25}}}$

$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{54.6 \times 10^{-56}}} = \frac{6.6 \times 10^{-34}}{7.39 \times 10^{-28}}$

$= 8.93 \times 10^{-7}\mathrm{m} = 893\mathrm{nm} = 8930\mathring{\mathrm{A}}$

ii. When a beam of light having frequency more than threshold frequency is made to fall on metals like alkali metals, electrons are ejected. These electrons are called photoelectrons and this phenomenon is called photoelectric effect.

90.
i. The frequency of the strong yellow line in the spectrum of sodium is $5.09 \times 10^{14}$ $s^{-1}$. Calculate the wavelength of the light in nanometer.
ii. Using s, p, d notations, describes the orbital with the following quantum numbers:
   - n = 3, l = 1, m = 0, (b) n = 1, l = 0
iii. Which quantum number distinguishes the electron in the same orbital? Name the principle involved.

**Ans. :**

i. Given, $\mathrm{n} = 5.09 \times 10^{14}\mathrm{s}^{-1}$,

$\mathrm{c} = 3 \times 10^{8}\mathrm{ms}^{-1}, \lambda = \ ?$

Wavelenth, $\lambda = \frac{\mathrm{c}}{\mathrm{v}} = \frac{3 \times 10^{8}\mathrm{ms}^{-1}}{5.09 \times 10^{14}\mathrm{s}^{-1}}$

$= 5.89 \times 10^{-7}\mathrm{m}$

$= 5.89 \times 10^{-7} \times 10^{9}\mathrm{nm} = 589\mathrm{nm}$

ii. (a) $3p_y$; (b) 1s
iii. Spin quantum number, Pauli exclusion principle.

91. Find energy of each of the photons which,

Have wavelength of 0.50 $\mathring{A}$.

**Ans. :** Energy (E) of a photon having wavelength $(\lambda)$ is given by the expression,

$E = \frac{hc}{\lambda}$

h = Planck's constant = $6.626 \times 10^{-34}$Js

c = velocity of light in vacuum = $3 \times 10^{8}$m/s

Substituting the values in the given expression of E:

$E = \frac{(6.626 \times 10^{-34})(3 \times 10^{8})}{0.50 \times 10^{-10}} = 3.976 \times 10^{-15}J$

$\therefore E = 3.98 \times 10^{-15}J$

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

**Ans. :** From de Broglie's equation,

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

Given,

Kinetic energy (K.E) of the electron = $3.0 \times 10^{-25}$J

Since $K.E = \frac{1}{2}mv^2$

$\therefore \text{Velocity (v)} = \sqrt{\frac{2K.E}{m}}$

$= \sqrt{\frac{2(3.0 \times 10^{-25}J)}{9.10939 \times 10^{-31}kg}}$

$= \sqrt{6.5866 \times 10^{4}}$

$v = 811.579\ ms^{-1}$

Substituting the value in the expression of $\lambda$ :



93. Give the number of electrons in the species $H_2^+$, $H_2$ and $O_2^+$

**Ans. :** $H_2^+$ :

Number of electrons present in hydrogen molecule ($H_2$) = 1 + 1 = 2

$\therefore$ Number of electrons in $H_2^+ = 2 - 1 = 1$

$H_2$ :

Number of electrons in $H_2 = 1 + 1 = 2$

$O_2^+$ :

Number of electrons present in oxygen molecule ($O_2$) = 8 + 8 = 16

$\therefore$ Number of electrons in $O_2^+ = 16 - 1 = 15$

94. Find

a. The total number and.

b. The total mass of protons in 34mg of $NH_3$ at STP.

Will the answer change if the temperature and pressure are changed?

**Ans. :**

a. 1 mol of $NH_3$ = 17g $NH_3$ = $6.022 \times 10^{23}$ molecules of $NH_3$

1 atom of $NH_3$ contains = 7 + 3 = 10 protons

∴ The number of protons in 1 mol of $NH_3$ = $6.022 \times 10^{24}$ protons.

Number of protons in 34mg of $NH_3 = \frac{(6.022 \times 10^{24} \times 34)}{17 \times 1000} = 1.2044 \times 10^{22}$ protons.

b. Mass of one proton = $1.6726 \times 10^{-27}$kg

∴ Mass of $1.2044 \times 10^{22}$ protons = $(1.6726 \times 10^{-27}) \times (1.2044 \times 10^{22})$kg = $2.0145 \times 10^{-5}$kg.

No, there will be no effect of temperature and pressure.

95. The unpaired electrons in Al and Si are present in 3p orbital. Which electrons will experience more effective nuclear charge from the nucleus?

**Ans. :** Nuclear charge is defined as the net positive charge experienced by an electron in a multi-electron atom.

The higher the atomic number, the higher is the nuclear charge. Silicon has 14 protons while aluminium has 13 protons. Hence, silicon has a larger nuclear charge of (+14) than aluminium, which has a nuclear charge of (+13). Thus, the electrons in the 3p orbital of silicon will experience a more effective nuclear charge than aluminium.

## * Case study based questions [8]

96. Read the passage given below and answer the following questions from (i) to (vi).

The atomic theory of matter was first proposed on afirm scientific basis by JohnDalton, a British schoolteacher in 1808. His theory, called Dalton's atomictheory, regarded the atom as the ultimate particle ofmatter Dalton's atomic theory was able to explainthe law of conservation of mass, law of constantcomposition and law of multiple proportion verysuccessfully. However, it failed to explain the results ofmany experiments.In mid 1850s many scientists mainlyFaraday began to study electrical dischargein partially evacuated tubes, known ascathode ray discharge tubes.Electrical discharge carried out in the modifiedcathode ray tube led to the discovery of canalrays carrying positively charged particles. Thecharacteristics of these positively chargedparticles are listed below.

1. Unlike cathode rays, mass of positivelycharged particles depends upon thenature of gas present in the cathode raytube. These are simply the positivelycharged gaseous ions.
2. The charge to mass ratio of the particlesdepends on the gas from which theseoriginate.
3. Some of the positively charged particlescarry a multiple of the fundamental unitof electrical charge.
4. The behaviour of these particles in themagnetic or electrical field is opposite tothat observed for electron or cathoderays.

The smallest and lightest positive ion wasobtained from hydrogen and was called proton. This positively charged particle wascharacterised in 1919. Later, a need was feltfor the presence of electrically neutral particleas one of the constituent of atom. Theseparticles were discovered by Chadwick (1932)by bombarding a thin sheet of beryllium byα-particles. When electrically neutral particleshaving a mass slightly greater than that ofprotons were emitted. He named theseparticles as neutrons.J. J. Thomson, in 1898, proposed that an atom possesses a spherical shape (radiusapproximately 10–10 m) in which the positivecharge is uniformly distributed. The electronsare embedded into it in such a manner as togive the most stable electrostatic arrangementMany different names are given tothis model, for example, plum pudding, raisinpudding or watermelon. This model can be visualised as a pudding or watermelon ofpositive charge with plums or seeds (electrons)embedded into it. An important feature of thismodel is that the mass of the atom is assumed to be uniformly distributed over theatom.Rutherford and his students (Hans Geiger andErnest Marsden) bombarded very thin gold foilwith α–particles. Rutherford’s famous α–particle scattering experiment.The observations of Scattering experiment are as follows-:

I. most of the α–particles passed throughthe gold foil undeflected.
II. a small fraction of the α–particles wasdeflected by small angles.
III. a very few α–particles (~1 in 20,000)bounced back, that is, were deflected bynearly 180°.

On the basis of observations andconclusions from this experiment, Rutherford proposed the nuclearmodel of atom. According to this model:

1. The positive charge and most of the massof the atom was densely concentrated inextremely small region. This very smallportion of the atom was called nucleusby Rutherford.
2. The nucleus is surrounded by electronsthat move around the nucleus with a veryhigh speed in circular paths called orbits.Thus, Rutherford’s model of atomresembles the solar system in which thenucleus plays the role of sun and theelectrons that of revolving planets.
3. Electrons and the nucleus are held together by electrostatic forces of attraction.

i. The atomic theory of matter was first proposed on afirm scientific basis by:
   a. John Dalton
   b. Ernest Rutherford
   c. J.Thomson
   d. Henry Moseley
ii. The cathode rays start from … and move towards the….
   a. Anode, Cathode
   b. Centre, Anode
   c. Cathod, Anode
   d. Cathod, Centre
iii. Negativelycharged particles in atoms, called…
   a. Protons
   b. Electrons
   c. Neutron
   d. Positron
iv. The smallest and lightest positive ion wasobtained from …. and was called proton.
   a. Oxygen
   b. Nitrogen
   c. Carbon
   d. Hydrogen
v. Electrically neutral particles having a mass slightly greater than that of protons, these particles termed as:
   a. Protons
   b. Electrons
   c. Neutron
   d. Positron
vi. J.J. Thomson’s atomic model is also named as:
   a. Plum pudding
   b. Raisin pudding
   c. Watermelon

d. All the above

**Ans. :**

i. (a) John Dalton
ii. (c) Cathod, Anode
iii. (b) Electrons
iv. (d) Hydrogen
v. (c) Neutron
vi. (d) All the above

97. Read the passage given below and answer the following questions from (i) to (v).

The presence of positive charge on thenucleus is due to the protons in the nucleus.As established earlier, the charge on the proton is equal but opposite to that of electron.Atomic number (Z) = number of protons inthe nucleus of an atom = number of electrons in a nuetral atom. protons and neutrons present in thenucleus are collectively known as nucleons.The total number of nucleons is termed asmass number (A) of the atom.

mass number (A) = number of protons (Z) + number of neutrons (n).

Isobars are the atoms with same massnumber but different atomic number forexample, $_6{}^4C$ and $_7{}^{14}N$. On the other hand, atomswith identical atomic number but differentatomic mass number are known as Isotopes.For example,considering of hydrogen atom again, 99.985% of hydrogen atoms contain only one proton.This isotope is called protium ($_1{}^1H$). Rest of thepercentage of hydrogen atom contains two otherisotopes, the one containing 1 proton and 1neutron is called deuterium ($^2{}_1D$, 0.015%)and the other one possessing 1 proton and 2neutrons is called tritium ($_1{}^3T$ )..the studiesof interactions of radiations with matter haveprovided immense information regarding thestructure of atoms and molecules. Neils Bohrutilised these results to improve upon themodel proposed by Rutherford. Twodevelopments played a major role in theformulation of Bohr's model of atom. Thesewere:

1. Dual character of the electromagneticradiation which means that radiations possess both wave like and particle likeproperties, and
2. Experimental results regarding atomicspectra.

James Maxwell (1870) was the first to givea comprehensive explanation about theinteraction between the charged bodies andthe behaviour of electrical and magnetic fieldson macroscopic level. He suggested that whenelectrically charged particle moves underaccelaration, alternating electrical and magnetic fields are produced and transmitted.These fields are transmitted in the forms ofwaves called electromagnetic waves orelectromagnetic radiation.radiations are characterised by theproperties, namely, frequency (ν) and wavelength $(\lambda)$.The SI unit for frequency (ν) is hertz(Hz, $s^{-1}$), after Heinrich Hertz. It is defined asthe number of waves that pass a given pointin one second.Wavelength should have the units of lengthand as you know that the SI units of length ismeter (m). Since electromagnetic radiationconsists of different kinds of waves of muchsmaller wavelengths, smaller units are used.In vaccum all types of electromagneticradiations, regardless of wavelength, travel atthe same speed, i.e., 3.0 × $10^8$m $s^{-1}$ (2.997925× $10^8$ $ms^{-1}$, to be precise). This is called speedof light and is given the symbol 'c'. Thefrequency (ν), wavelength $(\lambda)$ and velocity of light(c) are related by the following equation .

$$c = v\lambda$$

The other commonly used quantityspecially in spectroscopy, is the wavenumber.It is defined as the number of wavelengthsper unit length. Its units are reciprocal ofwavelength unit, i.e., $m^{-1}$. However commonlyused unit is $cm^{-1}$

i. The presence of positive charge on the nucleus is due to the .... in the nucleus.
   a. Protons
   b. Neutrons
   c. Electron
   d. Nucleons

ii. Atomic Number is denoted by:
   a. A
   b. Z
   c. N
   d. M

iii. Atomic Mass number is denoted by:
   a. M
   b. Z
   c. N
   d. A

iv. ... are the atoms with same mass number but different atomic number.
   a. Isotopes
   b. Allotropes
   c. Isobars
   d. None of above

v. Atoms with identical atomic number but different atomic mass number are known as ..
   a. Isotopes
   b. Allotropes
   c. Isobars
   d. None of above



**Ans. :**

i. (a) Protons
ii. (b) Z
iii. (b) Z
iv. (c) Isobars
v. (a) Isotopes

*** Given Section consists of questions of 5 marks each.** **[75]**

98. a. Calculate the wavelength and frequency of limiting line of Lyman series (Rydberg constant = 109677cm$^{-1}$)
   b. Give quantum numbers for electrons with highest energy in sodium atom (Z = 11)
   c. Which of the following sets of quantum numbers are not possible? Give reasons:
      i. $n = 1, 1 = 0, m_1 = 0, m_s = -\frac{1}{2}$
      ii. $n = 0, 1 = 0, m_1 = 0, m_s = -\frac{1}{2}$

**Ans. :**

a. For lyman series $n_1 - 1\ n_2 = \infty$ for limiting line,

$$\overline{v} = \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} = \frac{1}{n_2^2}\right)$$

$$= 109677 \times \frac{1}{1^2} = 109677\text{cm}^{-1}$$

$$\lambda = \frac{1}{109677}\text{cm}$$

$= 9.118 \times 10^{-6}\text{cm}$

$= 9.118 \times 10^{-8}\text{m}$

Frequency(v),

$= \frac{\text{Velocity(c)}}{\text{Wavelength}(\lambda)}$

$\text{v} = \frac{3 \times 10^8 \text{ms}^{-1}}{9.118 \times 10^{-8}\text{m}} = 0.29 \times 10^{16}\text{s}^{-1}$

$\text{v} = 3.29 \times 10^{15}\text{s}^{-1}$

b. $\text{Na}(11) : 1\text{s}^2\ 2\text{s}^2\ 2\text{p}^6\ 3\text{s}^1$

$\text{n} = 1, 1 = 0, \text{m} = 0, \text{s} = +\frac{1}{2}$

c. (ii) is not possible because $\text{n} \neq 0$ i.e., n cannot be equal to zero.

99. When an electric discharge is passed through hydrogen gas, the hydrogen molecules dissociate to produce excited hydrogen atoms. These excited atoms emit electromagnetic radiation of discrete frequencies which can be given by the general formula.

$\bar{\text{v}} = 109677 \frac{1}{\text{n}_\text{i}^2} - \frac{1}{\text{n}_\text{f}^2}$

What points of Bohr’s model of an atom can be used to arrive at this formula? Based on these points derive the above formula giving description of each step and each term.

**Ans. :** The following point of Bohr's model of an atom can be used to arrive at the given formula:

i. Electrons revolve around the nucleus in circular orbits with fixed values of energy.

ii. When electron jumbs from one orbit to another, energy is emitted of absorbed.

Derivation of the given formula: The energy of electron in the n^th stationary state is given by,

Where, $\text{E}_\text{n} = \frac{-2\pi^2\text{me}^4}{\text{n}^2\text{h}^2}$

m = mass of electron

e = Charge on electron

h = Planck's constant

When electron jumps from outer $\text{n}_2$ to inner orbit $\text{n}_1$ the difference of energy $(\Delta\text{E})$ is emitted.

$$\Delta\text{E} = \text{E}_2 - \text{E}_1 = \frac{-2\pi^2\text{me}^4}{\text{n}_2^2\text{h}^2} - \left(\frac{-2\pi^2\text{me}^4}{\text{n}_1^2\text{h}^2}\right)$$

$$= \frac{-2\pi^2\text{me}^4}{\text{h}^2} - \left(\frac{1}{\text{n}_1^2} - \frac{1}{\text{n}_2^2}\right)$$

$$\bar{\text{v}} = \frac{\Delta\text{E}}{\text{hc}} = \frac{2\pi^2\text{me}^4}{\text{ch}^3}\left(\frac{1}{\text{n}_1^2} - \frac{1}{\text{n}_2^2}\right)$$

By putting values of $\pi$, m, c, h and e we get,

$$\bar{\text{v}} = 109677\left(\frac{1}{\text{n}_\text{i}^2} - \frac{1}{\text{n}_\text{f}^2}\right)$$

100. Following results are observed when sodium metal is irradiated with different wavelengths. Calculate

a. Threshold wavelength.

b. Planck’s constant.

| | | | |
|---|---|---|---|
| $\lambda(\text{nm})$ | 500 | 450 | 400 |

| | | | |
|---|---|---|---|
| $v \times 10^{-5} (\text{cm s}^{-1})$ | 2.55 | 4.35 | 5.35 |

**Ans. :**

a. Assuming the threshold wavelength to be $\lambda_0 \text{nm} \ (= \lambda_0 \times 10^{-9} \text{m})$, the kinetic energy of the radiation is given as:

$$h(v - v_0) = \frac{1}{2}mv^2$$

Three different equalities can be formed by the given value as:

$$hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = \frac{1}{2}mv^2$$

$$hc\left(\frac{1}{500 \times 10^9} - \frac{1}{\lambda_0 \times 10^{-9} m}\right) = \frac{1}{2}m(2.55 \times 10^{+5} \times 10^{-2} ms - 1)$$

$$\frac{hc}{10^{-9} m}\left[\frac{1}{500} - \frac{1}{\lambda_0}\right] = \frac{1}{2}m(2.55 \times 10^{+3} ms^{-1})^2 \, ..(1)$$

Similarly,

$$\frac{hc}{10^{-9} m}\left[\frac{1}{450} - \frac{1}{\lambda_0}\right] = \frac{1}{2}m(3.45 \times 10^{+3} ms^{-1})^2 \ldots (2)$$

$$\frac{hc}{10^{-9} m}\left[\frac{1}{400} - \frac{1}{\lambda_0}\right] = \frac{1}{2}m(5.35 \times 10^{+3} ms^{-1})^2 \ldots (3)$$

Dividing equation (3) by equation (1):

$$\frac{\left[\frac{\lambda_0 - 400}{400\lambda_0}\right]}{\left[\frac{\lambda_0 - 500}{500\lambda_0}\right]} = \frac{(5.35 \times 10^{+3} ms^{-1})^2}{(2.55 \times 10^{+3} ms^{-1})^2}$$

$$\frac{5\lambda_0 - 2000}{4\lambda_0 - 2000} = \left(\frac{5.35}{2.55}\right)^2 = \frac{28.6225}{6.5025}$$

$$\frac{5\lambda_0 - 2000}{4\lambda_0 - 2000} = 4.40177$$

$$17.6070\lambda_0 - 5\lambda_0 = 8803.537 - 2000$$

$$\lambda_0 = \frac{6805.537}{12.607}$$

$$\lambda_0 = 539.8 \text{nm}$$

$$\lambda_0 \simeq 540 \text{nm}$$

$\therefore$ Threshold wavelength $(\lambda_0) = 540 \text{nm}$



**Note:** part (b) of the question is not done due to the incorrect values of velocity given in the question.

b.

$$\frac{5\lambda_0 - 2000}{4\lambda_0 - 2000} = \left(\frac{5.35}{2.55}\right)^2 = \frac{28.6225}{6.5025}$$

$$\frac{5\lambda_0 - 2000}{4\lambda_0 - 2000} = 4.40177$$

$$17.6070\lambda_0 - 5\lambda_0 = 8803.537 - 2000$$

$$\lambda_0 = \frac{6805.537}{12.607}$$

$$\lambda_0 = 539.8 \text{nm}$$

$$\lambda_0 \simeq 540 \text{nm}$$

101. The work function for caesium atom is 1.9eV. Calculate,

a. The threshold wavelength.

b. The threshold frequency of the radiation.

If the caesium element is irradiated with a wavelength 500nm, calculate the kinetic energy and the velocity of the ejected photoelectron.

**Ans. :** It is given that the work function ($W_0$) for caesium atom is 1.9eV.

a. From the expression, $W_0 = \frac{hc}{\lambda_0}$ we get:

$\lambda_0 = \frac{hc}{W_0}$

Where,

$\lambda_0$ = threshold wavelength

h = Planck's constant

c = velocity of radiation

Substituting the values in the given expression of $(\lambda_0)$ :

$\lambda_0 = \frac{(6.626\times10^{-34}Js)(3.0\times10^{8}ms^{-1})}{1.9\times1.602\times10^{-19}J}$

$\lambda_0 = 6.53 \times 10^{-1}m$

Hence, the threshold wavelength $\lambda_0$ is 653nm.

b. From the expression, $W_0 = hv_0$ we get:

$v_0 = \frac{W_0}{h}$

Where,

$\nu_0$ = threshold frequency

h = Planck's constant

Substituting the values in the given expression of $\nu_0$:

$v_0 = \frac{1.9\times1.602\times10^{-19}J}{6.626\times10^{-34}Js}$

(1eV = 1.602 × $10^{-19}$J)

$\nu_0$ = 4.593 × $10^{14}s^{-1}$

Hence, the threshold frequency of radiation ($\nu_0$) is 4.593 × $10^{14}s^{-1}$.



According to the question:

Wavelength used in irradiation (λ) = 500nm

Kinetic energy = h (ν – $\nu_0$)

$= hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$

$= (6.626 \times 10^{-34}Js)(3.0 \times 10^{8}ms^{-1})\left(\frac{\lambda_0-\lambda}{\lambda\lambda_0}\right)$

$= (1.9878 \times 10^{-26}Js)\left[\frac{(653-500)10^{-9}m}{(653)(500)10^{-18}m^2}\right]$

$= \frac{(1.9878\times10^{-26})(153\times10^{9})}{(653)(500)}J$

$= 9.3149 \times 10^{-20}J$

Kinetic energy of the ejected photoelectron $= 9.3149 \times 10^{-20}J$

Since $K.E = \frac{1}{2}mv^2 = 9.3149 \times 10^{-20}J$

$v = \sqrt{\frac{2(9.3149\times10^{-20}J)}{9.10939\times10^{-31}kg}}$

$= \sqrt{2.0451 \times 10^{11}m^2s^{-2}}$

$v = 4.52 \times 10^5 ms^{-1}$

Hence, the velocity of the ejected photoelectron (v) is $v = 4.52 \times 10^5 ms^{-1}$.

102. Nitrogen laser produces a radiation at a wavelength of 337.1nm. If the number of photons emitted is $5.6 \times 10^{24}$, calculate the power of this laser.

**Ans. :** Power of laser = Energy with which it emits photons

$$\text{Power} = E = \frac{Nhc}{\lambda}$$

Where,

N = number of photons emitted

h = Planck's constant

c = velocity of radiation

$\lambda$= wavelength of radiation

Substituting the values in the given expression of Energy (E):

$$E = \frac{(5.6\times10^{24})(6.626\times10^{-34}Js)(3\times10^{8}ms^{-1})}{(337.1\times10^{-9}m)}$$

$= 0.3302 \times 10^7 J$

$= 3.33 \times 10^6 J$

Hence, the power of the laser is $3.33 \times 10^6 J$.

103. What is the wavelength of light emitted when the electron in a hydrogen atom undergoes transition from an energy level with n = 4 to an energy level with n = 2?

**Ans. :** The $n_i = 4$ to $n_f = 2$ transition will give rise to a spectral line of the Balmer series. The energy involved in the transition is given by the relation,

$$E = 2.18 \times 10^{-18}\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$$

Substituting the values in the given expression of E:

$$E = 2.18 \times 10^{-18}\left[\frac{1}{4^2} - \frac{1}{2^2}\right]$$

$$= 2.18 \times 10^{-18}\left[\frac{1-4}{16}\right]$$

$$= 2.18 \times 10^{-18} \times \left(-\frac{3}{16}\right)$$

$E = -(4.0875 \times 10^{-19} J)$

The negative sign indicates the energy of emission.

Wavelength of light emitted $(\lambda) = \frac{hc}{E}$

$$\left(\text{since } E = \frac{hc}{\lambda}\right)$$

Substituting the values in the given expression of $\lambda$ :

$$\lambda = \frac{(6.626\times10^{-34})(3\times10^{8})}{4.0875\times10^{-19}}$$

$\lambda = 4.8631 \times 10^{-7} m$

$= 486.3 \times 10^{-9} m$

$= 486 nm$

104. Yellow light emitted from a sodium lamp has a wavelength $(\lambda)$ of 580 nm. Calculate the frequency (ν) and wavenumber $(\bar{v})$ of the yellow light.

**Ans. :** From the expression,

$\lambda = \frac{c}{v}$

We get,

$v = \frac{c}{\lambda} \ldots (1)$

Where,

ν = frequency of yellow light

c = velocity of light in vacuum = $3 \times 10^8$ m/s

λ = wavelength of yellow light = 580nm = $580 \times 10^{-9}$ m

Substituting the values in expression (i)

$v = \frac{3\times10^8}{580\times10^{-9}} = 5.17 \times 10^{14}\ s^{-1}$

Thus, frequency of yellow light emitted from the sodium lamp

= $5.17 \times 10^{14}\ s^{-1}$

Wave number of yellow light, $\bar{v} = \frac{1}{\lambda}$

$= \frac{1}{580\times10^{-9}} = 1.72 \times 10^6\ m^{-1}$

105. Write the electronic configurations of the following ions:

a. $H^-$

b. $Na^+$

c. $O^{2-}$

d. $F^-$



**Ans. :**

a. **$H^-$ ion**

The electronic configuration of H atom is $1s^1$.

A negative charge on the species indicates the gain of an electron by it.

∴ Electronic configuration of $H^-$ = $1s^2$

b. **$Na^+$ ion**

The electronic configuration of Na atom is $1s^2\ 2s^2\ 2p^6\ 3s^1$.

A positive charge on the species indicates the loss of an electron by it.

∴ Electronic configuration of $Na^+$ = $1s^2\ 2s^2\ 2p^6\ 3s^0$ or $1s^2\ 2s^2\ 2p^6$

c. **$O^{2-}$ ion**

The electronic configuration of 0 atom is $1s^2\ 2s^2\ 2p^4$.

A dinegative charge on the species indicates that two electrons are gained by it.

∴ Electronic configuration of $O^{2-}$ ion = $1s^2\ 2s^2\ p^6$

d. **$F^-$ ion**

The electronic configuration of F atom is $1s^2\ 2s^2\ 2p^5$.

A negative charge on the species indicates the gain of an electron by it.

∴ Electron configuration of $F^-$ ion = $1s^2\ 2s^2\ 2p^6$

106.

The electron energy in hydrogen atom is given by $E_n = \frac{(-2.18 \times 10-18)}{n^2} J$. Calculate the energy required to remove an electron completely from the n = 2 orbit. What is the longest wavelength of light in cm that can be used to cause this transition?

**Ans. :** $E_n = \frac{(-2.18 \times 10-18)}{n^2} J$

Energy required for ionization from n = 2 is given by,

$\triangle E = E_\infty - E_2$

$= \left[\left(\frac{-2.18 \times 10^{-18}}{(\infty)^2}\right) - \left(\frac{-2.18 \times 10^{-18}}{(2)^2}\right)\right] J$

$= \left[\frac{2.18 \times 10^{-18}}{4} - 0\right] J$

$= 0.545 \times 10^{-18} J$

$\triangle E = 5.45 \times 10^{-19} J$

$\lambda = \frac{hc}{\triangle E}$

Here, $\lambda$ is the longest wavelength causing the transition.

$\lambda = \frac{(6.626 \times 10^{-34})(3 \times 10^8)}{5.45 \times 10^{-19}} = 3.647 \times 10^{-7} m$

$= 3647 \times 10^{-19} m$

$= 3647 \text{Å}$

107. If the velocity of the electron in Bohr's first orbit is 2.19 × 106ms$^{-1}$, calculate the de Broglie wavelength associated with it.

**Ans. :** According to de Broglie's equation,

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

Where,

$\lambda$ = wavelength associated with the electron

h = Planck's constant

m = mass of electron

v = velocity of electron

Substituting the values in the expression of $\lambda$ :

$\lambda = \frac{6.626 \times 10^{-34} Js}{(9.10939 \times 10^{-31} kg)(2.19 \times 10^6 ms^{-1})}$

$= 3.32 \times 10^{-10} m = 3.32 \times 10^{-10} m \times \frac{100}{100}$

$= 332 \times 10^{-12} m$

$\lambda = 332 pm$

$\therefore$ Wavelength associated with the electron = 332pm

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

**Ans. :** For He$^+$ ion, the wave number $(\bar{v})$ associated with the Balmer transition, n = 4 to n = 2 is given by:

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

Where,

$n_1 = 2$

$n_2 = 4$

Z = atomic number of helium

$\bar{v} = \frac{1}{\lambda} = R(2)^2\left(\frac{1}{4} - \frac{1}{16}\right)$

$= 4R\left(\frac{4-1}{16}\right)$

$\bar{v} = \frac{1}{\lambda} = \frac{3R}{4}$

$\Rightarrow \lambda = \frac{4}{3R}$

According to the question, the desired transition for hydrogen will have the same wavelength as that of $He^+$.

$\Rightarrow R(1)^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = \frac{3R}{4}$

$\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = \frac{3}{4} \ldots (1)$

By hit and trail method, the equality given by equation (1) is true only when $n_1 = 1$and $n_2 = 2$.

$\therefore$ The transition for $n_2 = 2$ to $n = 1$ in hydrogen spectrum would have the same wavelength as Balmer transition $n = 4$ to $n = 2$ of $He^+$ spectrum.

109. Which of the following are isoelectronic species i.e., those having the same number of electrons?

$Na^+, K^+, Mg^{2+}, Ca^{2+}, S^{2-}, Ar.$

**Ans. : Notes:**

Isoelectronic are the species having same number of electrons.

A positive charge means the shortage of an electron.

A negative charge means gain of electron.

Number of electrons in $Na^+$ = 11 - 1 = 10

Number of electrons in $K^+$ = 19 - 1 = 18

Number of electrons in $Mg^{2+}$ = 12 - 2 = 10

Number of electrons in $Ca^{2+}$ = 20 - 2 = 18

Number of electrons in $S^{2-}$ = 16 + 2 = 18

Number of electrons in Ar = 18

Hence, the following are isoelectronic species:

1. $Na^+$ and $Mg^{2+}$ (10 electrons each)
2. $K^+$, $Ca^{2+}$, $S^{2-}$ and Ar (18 electrons each)

$\lambda = \frac{6.626 \times 10^{-34} Js}{(9.10939 \times 10^{-31} kg)(811.579\ ms^{-1})}$

$\lambda = 8.9625 \times 10^{-7} m$

Hence, the wavelength of the electron is $8.9625 \times 10^{-7}$m.

110. How much energy is required to ionise a H atom if the electron occupies n = 5 orbit? Compare your answer with the ionization enthalpy of H atom (energy required to

remove the electron from n = 1 orbit).

**Ans. :** $E_n = \frac{-21.8\times10^{-19}}{n^2 Jatom^{-1}}$

For ionization from 5th orbit, $n_1 = 5, n_2 = \infty$

$\therefore \triangle E = E_2 - E_1 = -21.8 \times 10^{-19} \times \left(\frac{1}{n2^2} - \frac{1}{n1^2}\right)$

$= 21.8 \times 10^{-19} \times \left(\frac{1}{n1^2} - \frac{1}{n2^2}\right)$

$= 21.8 \times 10^{-19} \times \left(\frac{1}{5^2} - \frac{1}{\infty}\right)$

$= 8.72 \times 10^{-20} J$

For ionization from 1st orbit, $n_1 = 1, n_2 = \infty$

$\therefore \triangle E' = 21.8 \times 10^{-19} \times \left(\frac{1}{1^2} - \frac{1}{\infty}\right) = 21.8 \times 10^{-19} J$

$\frac{\triangle E'}{\triangle E} = \frac{21.8\times10^{-19}}{8.72\times10^{-20}} = 25$

Hence, 25 times less energy is required to ionize an electron in the 5th orbital of hydrogen atom as compared to that in the ground state.

111. How many neutrons and protons are there in the following nuclei?

$^{13}_{06}C,\ ^{16}_{08}O,\ ^{24}_{12}Mg,\ ^{56}_{26}Fe,\ ^{88}_{38}Sr$

**Ans. :** $^{13}_{06}C$ :

Atomic mass = 13

Atomic number = Number of protons = 6

Number of neutrons = (Atomic mass) – (Atomic number)

= 13 – 6 = 7

$^{16}_{08}O$ :

Atomic mass = 16

Atomic number = 8

Number of protons = 8

Number of neutrons = (Atomic mass) – (Atomic number)

= 16 – 8 = 8

$^{24}_{12}Mg$ :

Atomic mass = 24

Atomic number = Number of protons = 12

Number of neutrons = (Atomic mass) – (Atomic number)

= 24 – 12 = 12

$^{56}_{26}Fe$ :

Atomic mass = 56

Atomic number = Number of protons = 26

Number of neutrons = (Atomic mass) – (Atomic number)

= 56 – 26 = 30

$^{88}_{38}Sr$ :

Atomic mass = 88

Atomic number = Number of protons = 38

Number of neutrons = (Atomic mass) – (Atomic number)

= 88 – 38 = 50

112. Show that the circumference of the Bohr orbit for the hydrogen atom is an integral multiple of the de Broglie wavelength associated with the electron revolving around the orbit.

**Ans. :** Since a hydrogen atom has only one electron, according to Bohr's postulate, the angular momentum of that electron is given by:

$\mathrm{mvr} = \mathrm{n}\frac{\mathrm{h}}{2\pi} \ldots (1)$

Where,

n = 1, 2, 3, …

According to de Broglie's equation:

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

or $\mathrm{mv} = \frac{\mathrm{h}}{\lambda} \ldots (2)$

Substituting the value of 'mv' from expression (2) in expression (1):

$\frac{\mathrm{hr}}{\lambda} = \mathrm{n}\frac{\mathrm{h}}{2\pi}$

or $2\pi\mathrm{r} = \mathrm{n}\lambda \ldots (3)$

Since $'2\pi\mathrm{r}'$ represents the circumference of the Bohr orbit (r), it is proved by equation (3) that the circumference of the Bohr orbit of the hydrogen atom is an integral multiple of de Broglie's wavelength associated with the electron revolving around the orbit.

----- "सफ़र में मुश्किलें आए ,तो हिम्मत और बढ़ती है.. अगर कोई रास्ता रोके, तो जुर्रत और बढ़ती है.. अगर बिकने पर आ जाओ, तो घट जाता है दम अक्सर.. ना बिकने का इरादा हो तो, कीमत और बढ़ती है।" -----