QB365 Question Bank Software Study Materials

Quantum Mechanical Model of Atom Important 2 Marks Questions With Answers (Book Back and Creative)

11th Standard

Chemistry

Total Marks : 60

2 Marks

30 x 2 = 60

1) The stabilisation of a half filled d - orbital is more pronounced than that of the p-orbital why?

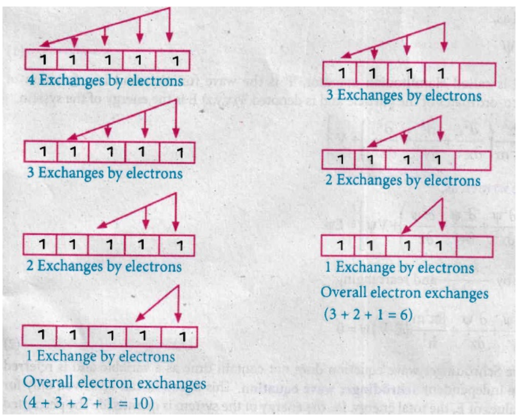
Answer : Energy electrons symmetry

This is due to the symmetrical distribution and exchange energy of given d- electrons. Symmetry leads to stability.

Exchange energy:

If two or more electrons with the same spin are present in degenerate orbitals, there is a possibility for exchanging their positions. During exchange process, the energy is released and the released energy is called exchange energy. If more number of exchanges are possible, more exchang energy in released. More number of exchanges are possible only in case of half filled and fully filled configurations.

For example, in chromium the electronic configuration is $[Ar]3d^5 4s^1$. The 3d orbital is half filled and there are ten possible exchanges as shown in figure. On the other hand only six exchanges are possible for $[Ar]3d^4 4s^2$ configuration. Hence, exchange energy for the half filled configuration is more. This increases the stability of half filled 3d orbitals.



The exchange energy is the basis for Hund's rule, which allows maximum multiplicity, that is electron pairing is possible only when all the degenerate orbitals contain one electron each.

2) How many orbitals are possible for n = 4?

Answer :

<table>
<tr><th>n</th><th>l</th><th>m</th><th>orbitals</th><th>Total no of orbitals</th></tr>
<tr><td></td><td>0</td><td>0</td><td>1</td><td rowspan="4">(1- 4s
+3 - 4P orbital
+5 - 4d orbital
+7 - 4f orbital)
=16</td></tr>
<tr><td rowspan="3">4</td><td>1</td><td>-1
0
+1</td><td>3</td></tr>
<tr><td>2</td><td>-2
-1
0
+1
+2</td><td>5</td></tr>
<tr><td>3</td><td>-3
-2
-1
0
+1
+2
+3</td><td>7</td></tr>
</table>

3) How many radial nodes for 2s, 4p, 5d and 4f orbitals exhibit? How many angular nodes

Answer :

Orbital	n	1	Radial node n-1-1	Angular node 1

2s	2	0	1	0
4p	4	1	2	1
5d	5	2	2	2
4f	4	3	0	3

4) Which quantum number reveal information about the shape, energy, orientation and size of orbitals?

Answer : a) Principal quantum number defines energy and size of an orbital.

b) Azimuthal quantum number defines shape of an orbital

c) Magnetic quantum number defines spatial orientation (direction) of an orbital.

5) Consider the following electronic arrangements for the d^5 configuration.

(a)

[↿⇂] [↿⇂] [↿] [ ] [ ]

(b)

[↿] [↿] [↿] [↿⇂] [ ]

(c)

[↿] [↿] [↿] [↿] [↿]

which of these represents the ground state

Answer : **(i) ground state :**

[↿] [↿] [↿] [↿] [↿]

This type of electronic configuration have ten possible arrangement (i.e. Half filled configuration is More).

6) The quantum mechanical treatment of the hydrogen atom gives the energy value:

$E_n = \frac{-13.6}{n_2} ev\ atom^{-1}$

(i) use this expression to find ΔE between n = 3 and n = 4

(ii) Calculate the wavelength corresponding to the above transition.

Answer : $E_n = \frac{-13.6}{n_2} ev \quad atom^{-1}$

n = 3 $E_3 = \frac{-13.6}{3^2} = \frac{-13.6}{9}$

= -1.51 ev $atom^{-1}$

n = 4 $E_4 = \frac{-13.6}{4^2} = \frac{-13.6}{16}$

= -0.85 ev $atom^{-1}$

$\triangle E = (E_4 - E_3)$ = (-0.85) - (-1.51) ev $atom^{-1}$

= (-0.85 + 1.51)

= 0.66eV $atom^{-1}$

(1eV = 1.6 x 10^{-19}J)

$\triangle E$ = 0.66 x 1.6 x 10^{-19}J

$\triangle E$ = 1.06 x 10^{-19}J

hv = 1.06 x 10^{-19}J

$\frac{hv}{\lambda}$ = 1.06 x 10^{-19}J

$\therefore \lambda = \frac{hc}{1.06 \times 10^{-19} J}$

$= \frac{6.626 \times 10^{-34} JS \times 3 \times 10^8 ms^{-1}}{1.06 \times 10^{-19} J}$

$\lambda = 1.875 \times 10^{-6} m$

7) Calculate the uncertainty in the position of an electron, if the uncertainty in its velocity is 5.7 x 10^5 ms^{-1}.

Answer : Given $\triangle v = 5.7 \times 10^5\ ms^{-1}$. $\triangle x$ = ?

According to Heisenbergs uncertainty principle $\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$

$\frac{h}{4\pi} = \frac{6.626 \times 10^{-34}}{4 \times 3.14} \mathrm{kgm^2\ s^{-1}} = 5.28 \times 10^{-35}$

$\Delta x \cdot \Delta \mathrm{p} \geq 5.28 \times 10^{-35}$

$\Delta x . \mathrm{m} \Delta \mathrm{v} \geq 5.28 \times 10^{-35}$

$\Rightarrow \Delta x \geq \frac{5.28 \times 10^{-35} \mathrm{kgm^2\ s^{-1}}}{9.1 \times 10^{-31}\ \mathrm{kg} \times 5.7 \times 10^5\ \mathrm{ms^{-1}}} \Rightarrow \Delta x \geq 1.017 \times 10^{-10}\ \mathrm{m}$

8) How many orbitals are possible in the 4^{th} energy level? (n = 4)

Answer : n = 4 l = 0,1,2,3

4 sub shells s, p, d & f.

I = 0 m_1 = 0 + one 4s orbital.

I = 1 m_1 = -1, 0, + 1 $\Rightarrow$ three 4p orbitals.

I = 2 m_1 = -2,:1, 0, +1, +2 $\Rightarrow$ five 4d orbitals.

I = 3 m_1 = -3, -2, -1,0, +1, +2, +3 $\Rightarrow$ seven 4f orbitals.

Over all 16 orbitals are possible.

9) Which ion has the stable electronic configuration? Ni^{2+} or Fe^{3+}.

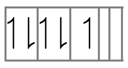
Answer : Electronic configuration of Fe^{3+} : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0\ 3d^5$

Electronic configuration of Ni^{2+} : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0\ 3d^8$

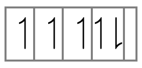
Fe^{3+} has stable $3d^5$ half filled configuration.

10) Consider the following electronic arrangements for the d^5 configuration.

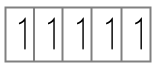
(a)



(b)

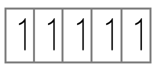


(c)



which configuration has the maximum exchange energy.

Answer : (ii) maximum exchange energy :



This type of electronic configuration have ten possible arrangement (i.e. Half filled configuration is More).

11) What are quantum numbers?

Answer : Quantum numbers are a set of four numbers which are used to specify the position, energy, shape, size, angular momentum, magnetic properties spin and orientation of an electron in an atom.

12) What is the charge and mass of an electron?

Answer : The charge of an electron is 1.602 x 10^{-19}coulomb

The mass of an electron is 9.11 x 10-^{31}kg

13) Give the number of electrons in the following species. H_2 , H_2 , O_2 and O_{2^-}

Answer : H_2 = 1 + 1 = $2e^-$

$H^+{}_2$; = 2 - 1 = le^-

O_2 = 8 + 8 = $16e^-$

O_2^- = 8 + 8 + 1= $17e^-$

14) How many neutrons and protons are there in the Following nuclei?

$^{13}_{6}C, ^{18}_{2}O. ^{24}_{12}Mg, ^{56}_{26}Fe, ^{38}_{88}Sr$

Answer :

Nucleus	Atomic Number (Z)	Mass Number (A)	Number of protons =Z	Number of Neutrons =A-Z
$^{13}_{6}C$	6	13	6	13 - 6 = 7
$^{18}_{2}O$	8	16	8	16 - 8- = 8
$^{24}_{12}Mg$	12	24	12	24 - 12 = 12
$^{56}_{26}Fe$	26	56	26	56 - 26 = 30
$^{38}_{88}Sr$	38	88	38	88 - 38 = 50

15) After the execution of the α-ray scattering experiment, what were the observations made by Rutherford? What did he conclude from his observations?

Answer :

	OBSERVATION	CONCLUSION
1	Most of the α-particles passed through the foil	Presence of large empty space in the atom
2.	Few α-particles were deflected by small angles	Positive charge is concentrated at a very small region and not uniformly distributed in whole atom
3.	Very few α-particles reflected completely at 180°	Positively charged core is known as nucleus

16) Write the values of all the four quantum numbers for all the electrons present in hydrogen and Helium atoms.

Answer : Hydrogen atom (H): Electronic configuration = IS1.

The four quantum number of electrons present in a hydrogen atom is

n = 1 l = 0; m = 0; s = $+\frac{1}{2}$

The four quantum number of two electrons present in a helium atom is

n = 1; l = 0; m = 0; s = + $\frac{1}{2}$

n = 1; l = 0; m = 0; s = + $\frac{1}{2}$

17) Write the values of four quantum numbers present in the last electron in, an atom having the electronic configuration

(i) $1s^2$ $2s^2$ $2p^1$

(ii) $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^2$.

Answer : (i) The last electron is the 'one' electron present in 'p' sub level.

i.e., n = 2; l = 1; m = -1,0 or + 1,s = + 1/2 or - 1/2

(ii) If the first electron present in 'p' subshell has the-following quantum numbers.

n = 3, l = 1, m = -1,0 (or) + 1, s = + 1/2,

the last electron has n = 3, l = 1, m = -1, 0 (or) + 1, s = - 1/2.

18) At what distance is the radial probability maximum for 1s orbital? What is this distance called?

Answer : 0.529 $\overset{o}{A}$, Bohr radius.

19) Bring out the similarities and dissimilarities between a 1s and 2s orbital.

Answer : **Similarities:**

(i) Both have similar shape.

(ii) Both have same angular momentum = $\sqrt{l(l+1)}\frac{h}{2\pi}$

Dissimilarities:

(i) Is orbital has no node while 2s orbital has one node.

(ii) Energy of 2s orbital is greater than Is orbital.

(iii) The size of the 2s orbital is larger than Is orbital.

20) How many radial f spherical nodes will be present in 5f orbital?

Answer : No. of radial nodes = n - I +1 = 5 - 3 - 1 = 1.

21) The ground state electronic configurations listed below here are incorrect. Explain what mistakes have been made in each and correct the electronic configuration.

(i) Al = $1s^2$ $2s^2$ $2p^4$ $3s^2$ $3p^6$.

(ii) B = $1s^2$ $2s^2$ $2p^5$

(iii) F = $1s^2$ $2s^2$ $2p^5$.

Answer : (i) In AI, 2p should be filled before filling 3s, orbital states.

$\therefore$ correct electronic configuration is $1s^2$ $2s^2$ $2p^6$ $3s^2$ $2p^1$

(ii) In B, total electrons = 5. Electronic configuration is $1s^2$ $2s^2$ $2p^1$

(iii) In F, total electrons = 9. Electronic configuration is $1s^2$ $2s^2$ $2p^5$.

22) Chromium (Z = - 24) and copper (Z = 29), should have the configuration.

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

Cu = $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^9$ $4s^2$

But their actual configuration are Cr = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ and
Cu = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ Explain the reason.

Answer : The reasons are:

(i) **Symmetrical distribution:** $3d^5$(half-filled) and $3d^{10}$ (completely filled) one more symmetrical and hence more stable.

(ii) **Exchange energy**: Electrons with parallel spins in degenerate orbitals tend to exchange their positions. As a result, energy is released. This energy is called exchange energy. Greater the exchange energy, greater is the stability.

23) How many unpaired electrons are present in the ground state of

(i) Cr^{3+} (Z = 24)

(ii) Ne (Z = 10)

Answer : (i) Cr (Z = 24) $Is^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$

Cr^{3+} - $Is^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4$.

It contains 4 unpaired electrons.

(ii) Ne (Z = 10) $1s^2 2s^2\ 2p^6$. No unpaired electrons in it.

24) Explain about theory of electromagnetic radiation.

Answer : (i) The theory of electromagnetic radiation states that a moving charged particle should continuously loose its energy in the form of radiation.

(ii) Therefore, the moving electron in an atom should continuously loose its energy and finally collide with nucleus resulting in the collapse of the atom.

25) What are ψ and ψ^2?

Answer : (i) ψ itself has no physical meaning but it represents an atomic orbital.

(ii) ψ^2 is related to the probability of finding the electrons within a given volume of space.

26) The energies of the same orbital decreases with an increase in the atomic number. Justify this statement.

Answer : The energy of the 2s orbital of hydrogen atom is greater than that of 2s orbital of lithium and that of lithium is greater than that of sodium and so on because H (Z = 1), Li (Z = 3) and Na (Z = 11). When atomic number increases, the energies of the same orbital decreases.

$E_{2s}(H) > E_{2s}(Li) > E_{2s}(Na) > E_{2s}(K)$ ....

27) State Hund's rule of maximum multiplicity

Answer : It states that electron pairing in the degenerate orbitals does not take place until all the available orbitals contain one electron each.

28) Write a note on Rutherford's atom model.

Answer : In an atom there is a tiny positively charged nucleus at the centre. The electrons are moving around the nucleus with high speed in spiral orbits.

29) The exactly half filled and completely filled orbitals have greater stability than other partially filled configuration in degenerate orbitals. Why?

Answer : This can be explained on the basis of symmetry and exchange energy. For example chromium has the electronic configuration of [Ar] $3d^5\ 4s^1$ and not [Ar] $3d^4\ 4s^2$ due to the symmetrical distribution and exchange energies of d electrons.

30) What are the formulae for finding the number of radial nodes and angular nodes ?

Answer : The number of radial nodes = $(n - l - 1)$

The number of angular nodes = l

Where n - principal quantum number and l = angular momentum quantum number.