

## MODEL QUESTION ANSWER

### SEMESTER 1

#### INORGANIC CHEMISTRY Paper CC-1

#### CHEMICAL BONDING

EACH QUESTION CARRIES 1 MARK:

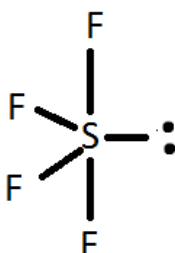
**1. What will be the probable structural arrangement for radius ratio 0.225-0.414 ?**

Ans : Tetrahedral

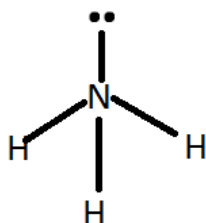
**2. Indicate the structures of the following with the help of the concept of hybridisation**

**i) SF<sub>4</sub> ii) NH<sub>3</sub>**

Ans : i) SF<sub>4</sub> : The central atom S in SF<sub>4</sub> is sp<sup>3</sup>d hybridised. The lone pair occupies the equatorial positions for minimum repulsion and it gives sea-saw structure.



ii) NH<sub>3</sub> : The central atom N in NH<sub>3</sub> is sp<sup>3</sup> hybridised. The lone pair of N occupies one of the tetrahedral sites and it gives pyramidal structure.



**3. Define lattice energy.**

Ans : Lattice energy is defined as the energy released when one mole of ionic crystal is formed from one mole of gaseous cation and one mole of gaseous anions each, when these are separated from each other by an infinite distance.

## SHORT ANSWER TYPE QUESTIONS :

**1. BaO has higher m.p than NaCl. Explain why? 2**

Ans : The significantly Higher m.p of BaO is attributed to the stronger cation anion interaction between the doubly charged Ba  $2+$  and  $O^{2-}$  as compared to singly charged ions in NaCl crystal.

**2. The hardness of SrO is higher than LiCl. Explain why? 2**

Ans: LiCl and SrO have the same NaCl type structure and same interionic separations of 257 pm. Their hardness increases as we move from singly charged  $Li^+$  and  $Cl^-$  to doubly charged  $Sr^{2+}$  and  $O^{2-}$ .

**3. Mention with example one limitation of radius ratio rule. 3**

Ans: An ion is considered as a sphere for determining the optimum arrangement of ions in the crystal lattice. This is far from reality and serious errors can be made if anions get polarised and the bonding has some partial covalent characters.

For example, the radius ratio of AgI is 0.52 which is indicative of co-ordination no 6 but actually it is 4 co-ordinated.

**4. How does Fajans' rule explain the relative covalent/ionic character of the following pairs of the compounds? 3 × 2 = 6**

**i FeCl<sub>2</sub>, FeCl<sub>3</sub> ii LiI, CsI, iii CuCl, NaCl**

Ans: i) As both  $Fe^{2+}$  and  $Fe^{3+}$  are almost same in size but the later one has greater charge. Thus according to Fajans' rule  $Fe^{3+}$  will have greater polarising power than  $Fe^{2+}$  and hence  $FeCl_3$  will be more covalent than  $FeCl_2$ .

ii) As both Li and Cs have same charge but the later one has greater size. Thus according to Fajans' rule Li will have greater polarising power than Cs and hence LiI will be more covalent than CsI.

iii) According to Fajans' rule , cations with pseudo-noble gas electronic configuration(18 electrons in outermost shell) have greater polarising power than a cation having noble gas electronic configuration in outermost shell. Here  $Cu^{2+}$  has pseudo-noble gas electronic configuration and  $Na^+$  has noble gas electronic configuration. So CuCl is more covalent than NaCl

**5. Calculate the heat of formation ( $\Delta H_f$ ) of KF from its elements from the following data by the use of Born-Haber cycle. 2**

**Sublimation energy of potassium (S) = 87.8 KJ mol<sup>-1</sup>**

**Dissociation energy of F<sub>2</sub> (D) = 158.9 kJmol<sup>-1</sup>**

**Ionization energy of K(g)(I) = 414.2 kJmol<sup>-1</sup>**

**Electron affinity for F(g)(E) = -334.7 kJmol<sup>-1</sup>**

**Lattice energy of KF (U<sub>0</sub>) = -807.5 kJmol<sup>-1</sup>**

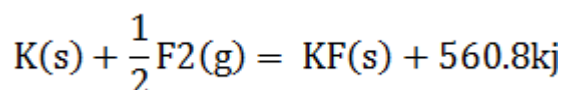
Solution: Substituting the values in the following equation.

$$\Delta H_f = S + \frac{1}{2}D + I + E + U_0$$

$$\Delta H_f = 87.8 + 1/2 (158.9) + 414.2 + (-334.7) + (-807.5)$$

$$= -560.8 \text{ kJmol}^{-1}$$

This can be represented as:



# Atomic Structure

## 1. Discuss the physical significance of $\psi$ and $\psi^2$ . 3

**Ans:-** In all wave equation, the square of the wave function is the property which has physical significance. For example- in case of light waves, the square of the amplitude of the wave at a point is proportional to the intensity of the light wave. Similarly, in electron wave motion the square of the  $\psi$  should represent the intensity. According to uncertainty principle, the position the the electron cannot be determined with certainty, that is greater the intensity of the wave function at a particular point, greater is the probability of location of the electron at that point. Thus  $\psi^2$  may be interpreted as being proportional to the electron density. If  $\psi^2$  is low, probability is low. In order to avoid the imaginary values  $\psi \cdot \psi^2$  is a complex conjugate of  $\psi$ . We expect that if  $\psi$  extends over a finite volume in space  $dx \times dy \times dz (=d\tau/dr)$  then the electron will be found in that volume. The wave function  $\psi$  may be positive, negative or imaginary but the probability density  $\psi \cdot \psi^*$  will always be positive and real. The probability of finding electron is finite which means  $\psi \cdot \psi^* d\tau$  gives the real values. If  $\psi$  has a real value then  $\psi = \psi^*$  and we can use  $\psi^2 d\tau / \psi^2 dr$  in place of  $\psi \cdot \psi^* d\tau$ .

## 2. What are the conditions which $\psi$ must satisfy to give meaningful solution. What are the characteristics of eigen function? 2

**Ans:-**  $\psi$  as a wave function must obey the following conditions. If it is has to give a meaningful result-

- $\psi$  must be single valued, that is it must have only one definite value at a particular point in a space.
- $\psi$  must be continuous at all points in the space that is there must not be sudden changes in the values of  $\psi$  when its variables are changed.
- $\psi$  must be a finite value over the space  $d\tau$  that the electron can occupy.
- $\psi$  must be normalized that is the probability of finding the electron is a space under the consideration must be unity.
- $\psi$  must become zero at infinite.

## 3. What is the physical significance of $\psi^*$ ? Explain mathematically. 1+1=2

**Ans:-** Solution of Schrödinger's wave equation give  $\psi$  values which can be real as well as imaginary but  $\psi^2$  is always real and gives positive values. This is because the square of even negative values is positive. If  $\psi$  has imaginary

values then  $\psi$  can be expressed as-

$$\Psi = a + ib$$

Where, a and b are real no. and  $i = \sqrt{-1}$

In such cases  $\psi$  is made real by multiplying it with its own complex conjugate  $\psi^*$  which is expressed as-

$$\psi = a + ib$$

The product obtained by multiplying  $\psi$  and  $\psi^*$  for real values of  $\psi$  is as -

$$\begin{aligned}\psi \cdot \psi^* &= (a + ib) \cdot (a - ib) \\ &= a^2 + i^2 b^2 \\ &= a^2 + b^2\end{aligned}$$

However, if  $\psi$  is real then  $\psi = \psi^*$  then  $\psi \times \psi^* = \psi^2$ .

#### 4. What are normalized and orthogonal wave function? 1+1=2

**Ans:-** Normalisation :-

$(\Psi \times \psi^*) d\tau$  is proportional to the probability of finding electron in the given volume element  $d\tau$ . However if we have a value of  $\psi$  such that the integration of  $\psi \cdot \psi^*$  from  $-\infty$  to  $+\infty$  that is over the entire space is not proportional but equal to the total probability of finding the electron, then the probability that the electron is present in the volume. Element  $d\tau$  becomes unity that is 100%. Mathematically it is expressed as-

$$\int_{-\infty}^{+\infty} \psi \cdot \psi^* \cdot d\tau = 1$$

This is the condition of normalization and  $\psi$  satisfying this equation is said to be normalized.

Sometimes,  $\psi$  may not be normalized wave function but then it is possible to multiply it by a constant 'N' so that  $N\psi$  is also a solution of wave equation. The problem is to choose proper value of 'N' so that  $N\psi$  is normalized. Mathematically the expression becomes-

$$\int_{-\infty}^{+\infty} (N\psi \cdot N\psi^*) d\tau = 1$$

$$\int_{-\infty}^{+\infty} (\psi \cdot \psi^*) d\tau = 1$$

$$\int_{-\infty}^{+\infty} (\psi \cdot \psi^*) d\tau = N^{-2} \quad (N = \text{normalizing constant})$$

Orthogonality:-

This means that at a particular wave function must be different from all form all other wave function over the entire space. This is reasonable

because of two particle are non-orthogonal wave function these description would not be unique as one wave function would be described in terms of other. Therefore, the wave function should be independent of each other that is orthogonal to each other. The condition for orthogonality is that the product of two wave function, integrated over the entire space must be equal to zero. This is if  $\psi_1$  and  $\psi_2$  represent the two different acceptable wave function of a system the if -

$$\int (\psi_1 \cdot \psi_2^*) d\tau = 0$$

The two wave function are said to be mutually orthogonal to each other.