

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5744

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Unique Paper Code : 2172011101

Name of the Paper : DSC-1: Atomic Structure & Chemical Bonding
(Inorganic Chemistry-I)

Name of the Course : **B.Sc. (H) Chemistry**

Semester : I

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **six** questions in all. **All** questions carry equal marks.
3. Question No. 1 is compulsory.
4. The questions should be numbered in accordance with the number in the question paper.
5. Non-programmable calculators may be used.

1. Explain any **five** of the following giving reasons :

(i) Ionic compounds are hard but brittle.

(ii) NCl_5 does not exist whereas PCl_5 does.

(iii) The first ionization enthalpy of Lithium is less than that of Beryllium but reverse is true for the second ionization enthalpy of Li.

(iv) Half-filled and completely filled orbitals are more stable.

(v) CdCO_3 decomposes at 350°C whereas CaCO_3 at 900°C .

(vi) NaCl is soluble in water but insoluble in CCl_4 .

(5×3)

P.T.O.

2. (a) State the limitations of Bohr's Model of an atom. What are the different types of quantum numbers? Give their significance.
- (b) Why is the atomic spectrum called the "fingerprint" of an element? In a hydrogen atom, an electron moves from the fifth to the second orbit. Calculate the wavelength of the corresponding spectral line. To which series of lines in the hydrogen spectrum does this spectral line belong, and in which region of the electromagnetic spectrum will it be observed?
- (c) Explain the following :
- (i) The electron gain enthalpy values of noble gases are taken to be zero.
 - (ii) The ionization energy of O is less than that of N. (5,5,5)
3. (a) Discuss the significance of Heisenberg's Uncertainty Principle for macro and microscopic particles. The uncertainty in position of a moving bullet of mass 0.02 kg is 5.0×10^{-6} m. Calculate the uncertainty in its velocity. ($h=6.626 \times 10^{-34}$ Js).
- (b) Differentiate between the following :
- (i) Atomic orbital and molecular orbital
 - (ii) Electron gain enthalpy and electronegativity
- (c) What is an angular wave function? Discuss its significance. Specify the quantum number(s) on which angular wave function depends. How many angular nodes are present in a $3p_z$ orbital? (5,5,5)
4. (a) Explain the geometry and shape of the following molecules using VSEPR Theory :
- (i) I_3^-
 - (ii) PCl_6^-

- (b) What is s-p mixing in Molecular Orbital Theory? Draw the MO diagram of C_2 molecule and explain its magnetic property and bond order.
- (c) What do you understand by radial probability? Draw the radial distribution function plots for the orbitals designated by the following quantum numbers:
- (i) $n=2, l=0$
 - (ii) $n=3, l=2$

Indicate the number of radial nodes present in each case. (5,5,5)

5. (a) Define dipole moment. Calculate percentage ionic character in HCl molecule if its dipole moment and inter nuclear distance is 1.03 D and 127 pm, respectively. ($D = 3.336 \times 10^{-30} \text{ Cm}$, charge on one electron = $1.6 \times 10^{-19} \text{ C}$).
- (b) What is Madelung's Constant? Explain, citing the example of NaCl. Write the Kapustinskii equation for lattice energy and give its advantages over Born-Landé equation.
- (c) List the salient features of Valence Bond Theory and discuss its limitations. (5,5,5)
6. (a) Calculate the limiting radius ratio for octahedral geometry with coordination number 6. Discuss the limitations of radius ratio rules.
- (c) Draw the Born-Haber Cycle for $NaCl_2$ and calculate its enthalpy of formation using following data:

Sublimation enthalpy of Na = 109 kJmol^{-1}

Dissociation enthalpy of Cl_2 = 243 kJmol^{-1}

First Ionization enthalpy of Na(g) to $Na^+(g)$ = 494 kJmol^{-1}

Second Ionization enthalpy of $Na^+(g)$ to $Na^{2+}(g)$ = 4561 kJmol^{-1}

Electron gain enthalpy of Cl(g) = $-348.5 \text{ kJmol}^{-1}$

Lattice Energy of $NaCl_2$ = -2155 kJmol^{-1}

Is the formation of $NaCl_2$ feasible? Justify your answer.

P.T.O.

- (d) Explain polarizing power and polarizability of an ion with examples. State the Fajan's rules. (5,5,5)
7. (a) Calculate the electronegativity of carbon from the following data: $\chi_{\text{H}}=2.1$. $E_{\text{H-H}} = 104.2 \text{ kcal mol}^{-1}$, $E_{\text{C-C}} = 83.1 \text{ kcal mol}^{-1}$ and $E_{\text{C-H}} = 98.8 \text{ kcal mol}^{-1}$. How is electronegativity affected by hybridization? Arrange the following in order of increasing acidic character and justify: methane, ethylene and acetylene.
- (b) CH_4 , NH_3 and H_2O have tetrahedral geometry, yet their bond angles and dipole moments are different. Explain.
- (c) What are isoelectronic ions? Arrange the following ions in increasing order of their sizes: N^{3-} , F^- , O^{2-} , Mg^{2+} , Na^+ & Al^{3+} . Justify your answer. (5,5,5)
8. (a) What do you understand by effective nuclear charge? Calculate the effective nuclear charge at the periphery of Chromium atom ($Z=24$). Discuss the limitations of Slater's rule.
- (b) Write a short note on any **two** of the following :
- (i) Bent's Rule and its applications
 - (ii) Aufbau principle and its limitations
 - (iii) Hund's rule of maximum multiplicity and its significance (5,5×2)