# ARSD College, University of Delhi

## Model Course Handout/Lesson Plan

| Course Name : B.Sc. (H) Chemistry, Section-B | | | | | | |
|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | **Course Title** | **Lecture (L)** | **Tutorial (T)** | **Practical (P)** | **Credit (C)** |
| I | 2172011101 | Inorganic Chemistry I: Atomic Structure & Chemical Bonding | 2 | 0 | 0 | 2 |
| Teacher/Instructor(s) | | Dr. Naorem Premjit Singh | | | | |
| Session | | 2022-23 | | | | |

**Course Objective:**

The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It also provides basic knowledge about ionic, covalent bonding and explains that chemical bonding is best regarded as a continuum between the two cases. It also discusses the periodicity in properties with reference to the *s* and *p* block, which is necessary in understanding their group chemistry.

**Course Learning Outcomes:**

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization energy and electron affinity of elements.
- Draw the plausible structures and geometries of molecules using Radius Ratio Rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Understand the concept of lattice energy using Born-Landé and Kapustinskii equation

**Lesson Plan:**

| Unit No. | Learning Objective | Lecture No. | Topics to be covered |
|---|---|---|---|
| 1. | Atomic Structure | 1-3 | Recapitulation of concept of atom in ancient India, Bohr's model of atom, its limitations and atomic spectrum of hydrogen atom |
| | | 4-5 | de Broglie equation, Heisenberg's Uncertainty Principle and its significance |
| | | 6-7 | Time independent Schrödinger's wave equation and significance of $\psi$ and $\psi^2$. |
| | | 8 | Quantum mechanical treatment of H- atom, Quantum numbers and their significance. |
| | | 9 | Normalized and orthogonal wave functions. Sign of wave functions. |
| | | 10-11 | Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. |
| | | 12 | Shapes of *s*, *p*, and *d o*rbitals, Relative energies of orbitals. |
| | | 13-14 | Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations. |
| 2. | Periodicity of Elements Covalent bond | 15-16 | Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. |
| | | 17 | Atomic and ionic radii. |
| | | 18 | Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. |
| | | 19 | Electron gain enthalpy and trends in groups and periods. |
| | | 20 | Electronegativity, Pauling scale of electronegativity, Variation of electronegativity with bond order and hybridization |
| 4 | Co-valent bond | 21-24 | Valence shell electron pair repulsion (VSEPR) theory, shapes of $H_2O$, $NH_3$, $PCl_3$, $PCl_5$, $SF_6$, $ClF_3$, $I_3$, $BrF_2^+$, $PCl_6^-$, $ICl_2^-ICl_4^-$, and $SO_4^{2-}$. Application of VSEPR theory in predicting trends in bond lengths and bond angles |
| | | 25-26 | Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. |
| | | 27-30 | Molecular orbital theory and MO diagrams of $N_2$,$O_2$, $C_2$, $B_2$, $F_2$, CO, NO and their ions; HCl |

**Evaluation Scheme:**

| No. | Component | Duration | Marks |
|---|---|---|---|
| 1. | Internal Assessment | | 25 |
| | • Quiz | | |
| | • Class Test | | |
| | • Attendance | | |
| | • Assignment | | |
| 2. | End Semester Examination | 3 hr | 75 |

| Details of the Course | | |
|---|---|---|
| **Unit** | **Contents** | **Contact Hours** |
| 1 | Atomic Structure: Recapitulation of the concept of atom in ancient India, Bohr's theory, its limitations and atomic spectrum of hydrogen atom, de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Postulates of wave mechanics, Time independent Schrödinger's wave equation, well behaved wave functions, significance of $\psi$ and $\psi 2$. Quantum mechanical treatment of H- atom, Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial function plots, Radial probability distribution plots, angular distribution curves. Shapes of *s*, *p*, and *d o*rbitals, Relative energies of orbitals. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations. | 14 |
| 2 | Periodic Properties of elements and periodic trends: Brief discussion of the following properties of the elements, with reference to *s*- & *p*-block and the trends:<br>(a) Effective nuclear charge, shielding or screening effect and Slater rules<br>(b) Atomic and ionic radii<br>(c) Ionization enthalpy, Successive ionization enthalpies<br>(d) Electron gain enthalpy<br>(e) Electronegativity, Pauling's scale of electronegativity, variation of electronegativity with bond order and hybridization. | 6 |
| 3 | Ionic bond:<br>Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Landé equation with derivation, Madelung constant, importance of Kapustinskii equation or lattice energy. Born-Haber cycle and its application.<br>Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. | 12 |
| 4 | Covalent bond: Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: $H_2O$, $NH_3$, $PCl_3$, $PCl_5$, $SF_6$, $ClF_3$, $I_3$, $BrF_2^+$, $PCl_6^-$, $ICl_2^-$, $ICl_4^-$, and $SO_4^{2-}$. Application of VSEPR in predicting trends in bond length and bond angles. | 13 |

| | | |
|---|---|---|
| | Valence Bond theory (*Heitler-London* approach). Hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule<br>Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.<br>Molecular orbital theory. Molecular orbital diagrams of homo and hetero diatomic molecules [$N_2$, $O_2$, $C_2$, $B_2$, $F_2$, CO, NO] and their ions; HCl (idea of s-p mixing and orbital interaction to be given). | |
| | Total | 45 |

**Suggested Books:**

| Sl. No. | Name of Authors/Books/Publishers | Year of Publication/Reprint |
|---|---|---|
| 1 | Lee, J.D.; (2010), Concise Inorganic Chemistry, Wiley India. | 2010 |
| 2 | Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education. | 2009 |
| 3 | Douglas, B. E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons. | 1994 |
| 4 | Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press. | 2010 |
| 5 | Pfennig, B.W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons. | 2015 |
| 6 | Housecraft, C. E.; Sharpe, A.G., (2018), Inorganic Chemistry, 5th Edition, Pearson. | 2018 |
| 7 | Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited. | 2002 |
| 8 | Miessler, G. L.; Fischer P. J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson. | 2014 |
| 9 | Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), Inorganic Chemistry, 6th Edition, Freeman & Company | 2014 |
| 10 | Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd. | 2014 |

| | |
|---|---|
| **Mode of Evaluation:** | Internal Assessment / End Semester Exam |