# KTE 311/3 – Selected Topics In Inorganic Chemistry

**Course Objectives** :1) To learn about cluster compounds, cage compounds and transition metal cluster complexes and their physical and chemical properties.
2) To learn about chemistry of halogens and group 15 elements.

| **Topic** | **Content** | **Number of lecture hours** | **Expected outcome – upon completion of this course, the student should be able to:** |
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| 1. Main Group Cluster, Cage and Ring Compounds | • Boron clusters<br>• Definition of borane and borohydride clusters<br>• Classification of borane and borohydride clusters according to Wade<br>• Molecular orbitals of borohydride clusters<br>• Synthesis and structure of borane compounds<br>• Characterization of boron, borane and borohydride compounds using $^{13}$B NMR<br>• Metaloborane cluster<br>• Carborane compounds<br>• Simple cage compounds such as allotropes of phosphorus<br>• Oxides and sulphides of phosphorus<br>• Oxides and sulphides of arsenic<br>• Inorganic analogues of benzene: borazine and cyclotriphosphazene<br>• Synthesis of borazine, cycloborazane and cyclotriphosphazene<br>• The structure and bonding in borazine and cyclotriphosphazene | 12 | • Know the concept and structural basis of cluster formation from the elements.<br>• Draw the 3D structure of cluster compounds.<br>• State the point group symmetry of clusters.<br>• Classify the cluster compounds as *closo*, *nido* or *arachno* according to Wade system.<br>• Know the LUMO and HOMO and the relative molecular orbital energy levels of Borohydride Cluster Compounds.<br>• Synthesize higher borane and borohydride compounds from commercially available diborane.<br>• Determine the structure of cluster compounds.<br>• Interpret the $^{13}$B NMR spectrum.<br>• Convert borane and borohydride compounds to metaloborane compounds.<br>• Convert borane and borohydride compounds to carborane compounds.<br>• Know the definition of Cage Compound.<br>• Know the basis for the formation of cage compounds.<br>• Write the name and structure of cage compounds.<br>• Describe the bonding theory in cage compounds.<br>• Compare the structure and bonding in borazine and cyclotriphosphazene compared to that of benzene.<br>• Compare the physical and chemical properties of borazine and cyclotriphosphazene to those of benzene.<br>• Describe the synthesis of borazine, cycloborazine and hexachlorocyclotriphosphazene from commercially available starting materials.<br>• Draw the structures of the tub and crown conformations of tetracyclotriphoshazene. |

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| | • Tetracyclotriphoshazene<br>• Anionic cyclic silicates<br>• Anionic cyclic metaphosphate<br>• Nitrogen-sulphur ring compounds<br>• Inorganic homocyclic systems | | • Draw the projection of $Si_3O_9^{6-}$ and those of higher silicates.<br>• Separate mixtures of metaphosphates using preparative thin layer chromatography in two dimensions.<br>• Describe the structure bonding and synthesis of nitrogen-sulphur ring compounds.<br>• Give examples of selenium, phosphorus and inorganic carbonyl homocyclic systems. |
| 2. Transition Metal Cluster Complexes and Chemistry of Halogen and Group 18 Elements | • The physical characteristics of First, Second and Third Row Transition Elements<br>• Cluster compounds of Nb and Ta<br>• Cluster compounds of Mo<br>• Cluster compounds of Re<br>• Cluster compounds of Fe, Ru and Os<br>• Metal-metal bond<br>• Two-centered multiple bond<br>• Physical properties, extraction and uses of halogens<br>• Synthesis of halide compounds<br>• Structure, bonding and reactions of halide compounds<br>• Interhalogen compounds<br>• Polyhalide compounds<br>• Halogen oxides and oxoanions<br>• Halogen compounds with variable oxidation states ranging from -1 to +7<br>• Physical characteristics of rare gases<br>• Chemistry of xenon | 12 | • Relate the physical characteristics of transition metals to their chemical reactivities.<br>• Determine the bond order of the bonds in transition metal cluster compounds.<br>• Describe the structure and bonding in transition metal cluster compounds.<br>• Use the 18 electron rule to predict the stability transition metal complexes.<br>• Use the Valence Bond Theory to explain the existence of metal – metal two centered multiple bond.<br>• Correlate the physical properties of the halogens with the reactivities of the elements in particular the oxidation states.<br>• Describe the synthesis of metal and organic halides.<br>• Draw the structures and describe the bonding in bridged dimeric and tetrameric halide compounds.<br>• List all the polyhalide and interhalogen compounds together with their structures as predicted by VSEPR Theory.<br>• Describe the synthesis, structure and acidity of halogen oxides and oxoanions.<br>• Predict the disproportionation of oxoanions using Frost Diagram.<br>• Describe the synthesis of halogen compounds with the halogens having oxidation states ranging from -1 to +7.<br>• Relate the physical characteristics of rare gases with their chemical reactivities.<br>• Describe the structure and bonding of xenon halides and oxides. |

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| 3. Group 15 Elements with Emphasis on Phosphorus-Nitrogen Compounds | • Introduction to the group 15 elements: nitrogen, phosphorus, arsenic, antimony and bismuth<br>• Hydrides, halides, oxohalides, oxides and oxoacids of the group 15 elements<br>• Nitrogen and phosphorus chemistry<br>• Phosphazene chemistry<br>• Synthesis of phosphazenes<br>• Structural characterization on cyclic phosphazenes | 12 | • Know some general features and trends of the physical and chemical properties of the group 15 elements. Also know their general occurrence, extraction and uses.<br>• Know the types and stabilities of the hydrides, halides and oxoacids of the group 15 elements. In particular, know the important reactions of $PCl_3$ and $PCl_5$.<br>• Understand the principal factors responsible for the differences between nitrogen and phosphorus chemistry.<br>• Understand that a phosphazene unit comprises P(V) doubly bonded to N(III) and with additional two substituents on the former element.<br>• Understand the variation in chemical bonding and reaction of hexachlorocyclotriphosphazene [$N_3P_3Cl_6$] as compared to that of hexachlorobenzene [$C_6Cl_6$].<br>• Know the general physical properties of phosphazene-based compounds<br>• Know the past and some current applications of phosphazene-based compounds.<br>• Understand the various methods for the preparation of cyclic, oligomeric (inclusive of cyclolinear and cyclomatric) and polymeric phosphazene-based compounds.<br>• Introduction to $^{31}P$ NMR spectroscopy and its utilization in structural elucidation of cyclotriphosphazenes. |
| | **TOTAL** | **36** | |