

## Inorganic Cumulative Exam

January 12, 2012

given by Laura Anderson

*Provide an appropriate answer for each question. Provide specific examples and avoid the use of generic groups such as R and X. Show your work and clearly indicate your final answer. There are 6 questions worth a total of 100 points.*

**1)** (10 pts) Atomic orbitals of the transition metals.

- a) Draw and label the five d-orbitals.
- b) Draw and label two of the f-orbitals.

**2)** (10 pts) Periodic Table

Draw the transition series of the periodic table. All three rows of Group 3 to Group 12 are required. There should be 30 elements in all.

**3)** (20 pts) Square planar transition metal catalysts.

- a) Give an example of a square planar transition metal catalyst (Specify the metals and the ligands. Do not use R groups). Give the oxidation state and d-electron count for the transition metal and give the total number of valence electrons in the complex.
- b) Give an example of a reaction that the catalyst catalyzes (Do not use R groups. Choose specific substrates). Draw the mechanism for this transformation.
- c) Draw a frontier molecular orbital diagram for a square planar complex and appropriately fill the diagram with the number of electrons associated with your chosen catalyst.

**4)** (20 pts) Bent metallocene transition metal catalysts.

- a) Give an example of a bent-metallocene (sandwich-complex) transition metal catalyst (Specify the metals and the ligands. Do not use R groups). Give the oxidation state and d-electron count for the transition metal and give the total number of valence electrons in the complex.
- b) Give an example of a reaction that the catalyst catalyzes (Do not use R groups. Choose specific substrates). Draw the mechanism for this transformation.

c) Draw a frontier molecular orbital diagram for a bent metallocene complex and appropriately fill the diagram with the number of electrons associated with your chosen catalyst.

**5)** (20 pts) Dinuclear coordination complexes.

a) Draw the structures of  $\text{Mo}_2(\text{O}_2\text{CCH}_3)_4$ ,  $\text{Rh}_2(\text{O}_2\text{CCH}_3)_4$ , and  $\text{Cu}_2(\text{O}_2\text{CCH}_3)_4$ .

b) Determine the oxidation state, the d-electron count, and the valence electron count of each of transition metal centers in these complexes.

c) State the bond order between the two transition metals in each of these complexes and explain why the bond orders are different depending on the identity of the metal center.

**6)** (20 pts)

a) Draw Grubbs' second generation catalyst. Provide an example of ring-closing metathesis using 5 mol % of this catalyst (Do not use R groups. Provide a specific example.). Illustrate the structure of the active catalyst for 95% of the turnovers during this transformation.

b) Provide an example of a Suzuki reaction and a Heck reaction. Do not use R groups. Provide a specific example, a specific palladium pre-catalyst, and a specific base. Explain the role of the base in each transformation.