

CH 431: INORGANIC CHEMISTRY

Prof. Emily Que

Welch 1.316

Tues, Thurs 11:00am-12:15 pm

UT-Austin Fall 2016

More detailed course info will be made available throughout the semester on the Piazza site

<https://piazza.com/utexas/fall2016/ch431/home>



**CHEMISTRY 431
INORGANIC CHEMISTRY
Fall 2016**

Syllabus

Lecture schedule: TTh, 11:00 am-12:30 pm Welch 1.316

Instructor: Prof. Emily Que, emilyque@cm.utexas.edu, Welch 4.314

Office hours: Tuesday 12:30-1:30 pm, Thursday 4:30-5:30 pm or by appointment.

Teaching assistants:

Spencer Kerns	spencer.kerns@utexas.edu
Kanchan Aggarwal	kanchan.uta@utexas.edu
José Enriquez	jsenriquez@utexas.edu
Rahul Kadakia	rkadakia@utexas.edu

TA office hours in Welch 2.306:

Th 12:30-1:30 pm
Mon TBD
Wed 5-6 pm
Friday 4-5 pm

Laboratory: Welch 5.140

Monday 2-5 pm	50615, Spencer Kerns
Monday 6-9 pm	50635, Spencer Kerns
Tuesday 2-5 pm	50620, Kanchan Aggarwal
Tuesday 6-9 pm	50640, Kanchan Aggarwal
Wednesday 9-12 pm	50605, Rahul Kadakia
Wednesday 2-5 pm	50625, José Enriquez
Thursday 2-5 pm	50630, José Enriquez
Friday 1-4 pm	50610, Rahul Kadakia



Syllabus

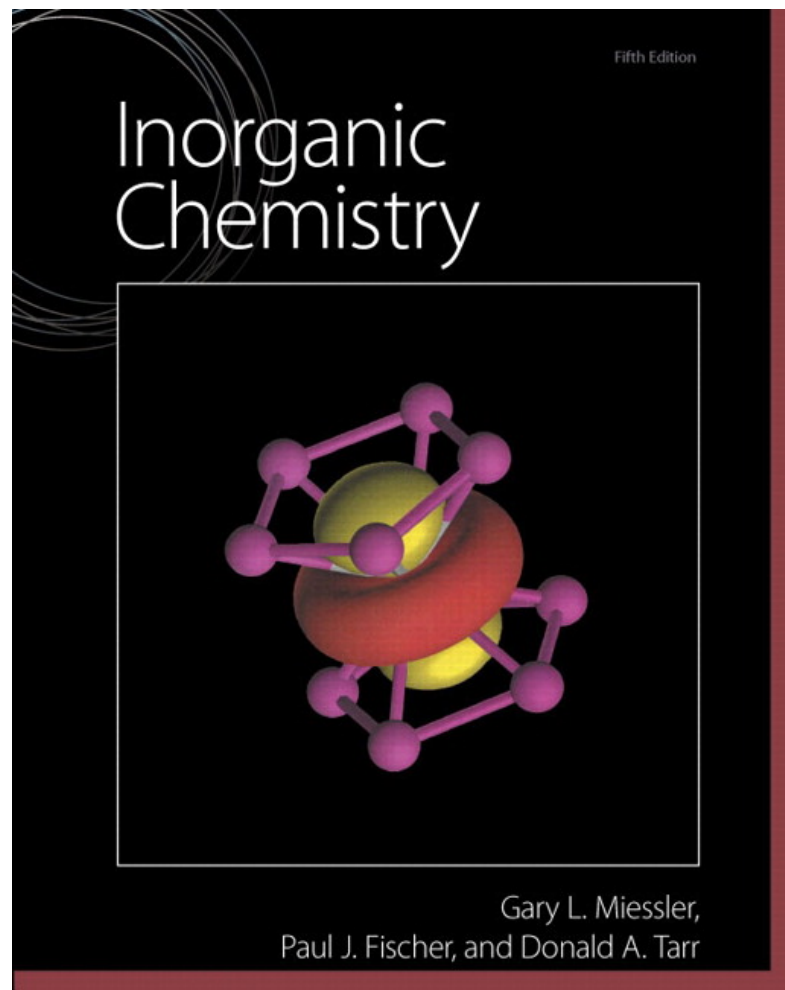
- **Attendance Policy:** Lecture attendance is strongly encouraged, as notes provided on the Piazza site may not fully recapitulate the material discussed in class.
- ***You are required to attend, on time your assigned laboratory period.*** Tardiness and absences will affect your laboratory grade as detailed in the Laboratory Manual available on Piazza.
 - The beginning of each laboratory session will include essential info about the experiment including introductory material and SAFETY considerations. Missing this portion of the lab session is unacceptable. Please respect your TAs and classmates and show up on time.



Syllabus

- **Textbook:** Miessler, Fischer, and Tarr “Inorganic Chemistry” 5th edition.
 - Older versions of this text may be used, but understand that there may be differences between the versions.
 - Suggested reading and problem sets will be posted to Piazza
- **Molecular Model Kit:**
 - The specified kit is good for inorganic and organic chemistry (\$23)

https://www.amazon.com/Molymod-MMS-009-Molecular-Inorganic-Chemistry/dp/B005RUTZ8Q/ref=sr_1_1?ie=UTF8&qid=1471718230&sr=8-1&keywords=molymod+inorganic+organic+student+set



Syllabus

- **Supplemental resources:**

- Other inorganic text books (Housecroft and Sharpe, Shriver and Atkins)
- CH301 and CH302 websites!!!
 - <https://ch301.cm.utexas.edu/>
 - <https://ch302.cm.utexas.edu/>
- Chemistry Wiki courtesy of UC Davis
 - http://chem.libretexts.org/Core/Inorganic_Chemistry



Syllabus

- **Webpage and Email Policy**

- We will be using Piazza for the main course website and online class discussion: <https://piazza.com/utexas/fall2016/ch431/home>
- *If you have questions regarding course material or logistics, submit them to the course website and not to me via personal email. I consider such questions to be public and will ask you to repost them to Piazza so that your colleagues can benefit from the discussion. Please check the website regularly! Announcements relevant to exams and other course logistics will be posted as well as periodic class polls.*
- Private emails: please include CH431 in the subject line
- *Canvas will be used, but only for quizzes and grades.*



Syllabus

- **Lecture Notes:**

- Lecture notes will be a combination of PowerPoint and handwritten notes displayed using the document camera. PowerPoint notes will typically be uploaded prior to lecture to facilitate your note taking. Document camera notes will be uploaded after lecture. Periodically, I will post a summary that identifies the key concepts of the material covered in class. Context for understanding these notes is critical and I encourage you to take your own notes during class to supplement these materials.
- *I also encourage you to ask questions during class.* If you are having trouble understanding a concept, then I can guarantee that you're not the only one in the room with that question.



Syllabus

- **Homework problems:**
- Suggested homework problems from MFT and supplementary problem sets will be posted on the Piazza site.
- It is your responsibility to keep up with the material using these problems as a guide to test your understanding, however we will not be grading homework questions.



Syllabus

- **Grades:** Your grades will be based on performance in both the lecture and laboratory portions of the course.
- Online quizzes: 10% of total grade
- 2 Midterm exams, 15% of total grade each, (30% of total grade)
- Final exam 25% of total grade
- Lab (35% of total grade): Your lab grade will comprise 30% of your total grade. This grade will come from pre-labs, lab reports and a final project.



Syllabus

- **Online quizzes:**

- 10 online quizzes will be administered to assess your understanding of the material. They will be posted on Fridays and due the following Wednesday. Quiz feedback will be given at the beginning of class each Thursday.
- These will be administered on the course **Canvas** site.
- <https://utexas.instructure.com/courses/1172966>
- Quiz due dates:
 - 7-Sep, 12-Sep, 21-Sep
 - 5-Oct, 12-Oct, 19-Oct, 26-Oct
 - 9-Nov, 16-Nov, 30-Nov



Syllabus

- **Midterm 1 date:** Tuesday, September 27, in lecture.
- **Midterm 2 date:** Tuesday November 1, in lecture.
- **Final exam date:** Monday, December 12, 2:00-5:00 pm
- We will hold two evening review sessions prior to each exam to help you prepare. Scheduling to be determined.



Syllabus

- **Laboratory:** More detailed information will be given to you during lab check-in (Aug 29-Sep 2)
- **Lab reports and Final Project:** Lab reports will be due at the beginning of your lab section one week after an experiment is completed. Lab report expectations are covered in your laboratory manual and will be further explained by your TA. A Final Project at the end of the semester will consist of a short PowerPoint presentation on a special topic of interest related to Inorganic Chemistry. Details to follow.



Syllabus

- Starting rubric for assignment of course grade:
 - A \geq 90
 - A- \geq 85
 - B+ \geq 80
 - B \geq 75
 - B- \geq 70
 - C+ \geq 65
 - C \geq 60
 - C- \geq 55
 - D \geq 45
 - F < 45
- This rubric is subject to change, any changes will be in favor of better grades.



Preliminary lecture schedule

Week	Date	Quiz?	Lecture Topics	MFT
1	25-Aug		Syllabus, introduction	Ch 1
2	30-Aug 1-Sep		Atomic structure and bonding	Ch 2,3
3	6-Sep 8-Sep	due 7-Sep		
4	13-Sep 15-Sep	due 12-Sep	Symmetry and Group Theory	Ch 4
5	20-Sep 22-Sep	due 21-Sep		
			Review for Midterm 1	
6	27-Sep 29-Sep		Midterm 1	
			Molecular Orbital Theory	Ch 5
7	4-Oct 6-Oct	due 5-Oct		
8	11-Oct 13-Oct	due 12-Oct	Coordination chemistry: structures and bonding	Ch 9,10,11
9	18-Oct 20-Oct	due 19-Oct		
10	25-Oct 27-Oct	due 26-Oct		
			Review for Midterm 2	
11	1-Nov		Midterm 2	



11	3-Nov		Reactions of Coordination complexes	Ch 12
12	8-Nov	due 9-Nov		
	10-Nov			Ch 13,14
13	15-Nov	due 16-Nov	Organometallic Chemistry	
	17-Nov			
14	22-Nov		Thanksgiving, no class	
	24-Nov			
15	29-Nov	due 30-Nov	Bioinorganic Chemistry	Ch 16
	1-Dec		Review for Final	
Finals week	12-Dec	Final 2:00-5:00 pm		

Essentially three major sections:
 Fundamentals of structure and bonding
 Chemistry of coordination compounds
 Applications of coordination compounds



Laboratory Schedule

See lab manual and Piazza site for more specific details for each section.

Week	Dates	Activity
1	24-Aug - 26-Aug	No lab
2	29-Aug - 2-Sep	Lab check-in, pre-lab and lab report expectations
3	5-Sep - 9-Sep	At home activity: how to search the scientific literature using SciFinder
4	12-Sep - 16-Sep	Thermochromism lab
5,6	19-Sep - 23-Sep 26-Sep - 30-Sep	Symmetry lab
7	3-Oct - 7-Oct	Electron paramagnetic resonance lab
8	10-Oct - 14-Oct	Cobalt Crystal field theory lab
9,10, 11,12	17-Oct - 21-Oct 24-Oct - 28-Oct 31-Oct - 4-Nov 7-Nov - 11-Nov	Ferrocene lab Molybdenum lab (see lab manual for specific lab schedule for each section)
14	21-Nov - 25-Nov	No lab, Thanksgiving
15	28-Nov - 2-Dec	Final project presentations



WHAT IS INORGANIC CHEMISTRY?



1
IA
11A

2
IIA
2A

13
IIIA
3A

14
IVA
4A

15
VA
5A

16
VIA
6A

17
VIIA
7A

18
VIIIA
8A

1
H
Hydrogen
1.008

3
Li
Lithium
6.941

11
Na
Sodium
22.990

19
K
Potassium
39.098

37
Rb
Rubidium
84.468

55
Cs
Cesium
132.905

87
Fr
Francium
223.020

4
Be
Beryllium
9.012

12
Mg
Magnesium
24.305

20
Ca
Calcium
40.078

38
Sr
Strontium
87.62

56
Ba
Barium
137.327

88
Ra
Radium
226.025

5
B
Boron
10.811

13
Al
Aluminum
26.982

21
Sc
Scandium
44.956

29
Cu
Copper
63.546

31
Ga
Gallium
69.732

49
In
Indium
114.818

67
Ho
Holmium
164.930

69
Tm
Thulium
168.934

71
Lu
Lutetium
174.967

6
C
Carbon
12.011

14
Si
Silicon
28.086

22
Ti
Titanium
47.88

30
Zn
Zinc
65.39

32
Ge
Germanium
72.61

50
Sn
Tin
118.71

68
Er
Erbium
167.26

70
Yb
Ytterbium
173.04

72
No
Nobelium
259.101

7
N
Nitrogen
14.007

15
P
Phosphorus
30.974

23
V
Vanadium
50.942

31
As
Arsenic
74.922

51
Sb
Antimony
121.760

61
Pm
Promethium
144.913

63
Eu
Europium
151.966

65
Tb
Terbium
158.925

67
Ho
Holmium
164.930

69
Tm
Thulium
168.934

71
Lu
Lutetium
174.967

8
O
Oxygen
15.999

16
S
Sulfur
32.066

24
Cr
Chromium
51.996

32
Se
Selenium
78.09

52
Te
Tellurium
127.6

62
Sm
Samarium
150.36

64
Gd
Gadolinium
157.25

66
Dy
Dysprosium
162.50

68
Er
Erbium
167.26

70
Yb
Ytterbium
173.04

72
No
Nobelium
259.101

9
F
Fluorine
18.998

17
Cl
Chlorine
35.453

25
Mn
Manganese
54.938

33
Br
Bromine
79.904

53
I
Iodine
126.904

63
Eu
Europium
151.966

65
Tb
Terbium
158.925

67
Ho
Holmium
164.930

69
Tm
Thulium
168.934

71
Lu
Lutetium
174.967

10
Ne
Neon
20.180

18
Ar
Argon
39.948

36
Kr
Krypton
84.80

54
Xe
Xenon
131.29

86
Rn
Radon
222.018

118
Uuo
Ununoctium
unknown

8
VIII
8

9
VIII
8

10
VIII
8

3
IIIB
3B

4
IVB
4B

5
VB
5B

6
VIB
6B

7
VIIB
7B

8
VIII
8

9
VIII
8

10
VIII
8

11
IB
1B

12
IIB
2B

57
La
Lanthanum
138.906

58
Ce
Cerium
140.115

59
Pr
Praseodymium
140.908

60
Nd
Neodymium
144.24

61
Pm
Promethium
144.913

62
Sm
Samarium
150.36

63
Eu
Europium
151.966

64
Gd
Gadolinium
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Tb
Terbium
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Dy
Dysprosium
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Ho
Holmium
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Er
Erbium
167.26

69
Tm
Thulium
168.934

70
Yb
Ytterbium
173.04

71
Lu
Lutetium
174.967

89
Ac
Actinium
227.028

90
Th
Thorium
232.038

91
Pa
Protactinium
231.036

92
U
Uranium
238.029

93
Np
Neptunium
237.048

94
Pu
Plutonium
244.064

95
Am
Americium
243.061

96
Cm
Curium
247.070

97
Bk
Berkelium
247.070

98
Cf
Californium
251.080

99
Es
Einsteinium
[254]

100
Fm
Fermium
257.095

101
Md
Mendelevium
258.1

102
No
Nobelium
259.101

103
Lr
Lawrencium
[262]

Alkali
Metal

Alkaline
Earth

Transition
Metal

Semimetal

Nonmetal

Basic
Metal

Halogen

Noble
Gas

Lanthanide

Actinide

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chemistry.about.com
sciencenotes.org

Inorganic chemistry encompasses the entire periodic table.
This course will mainly focus on the chemistry of transition metals

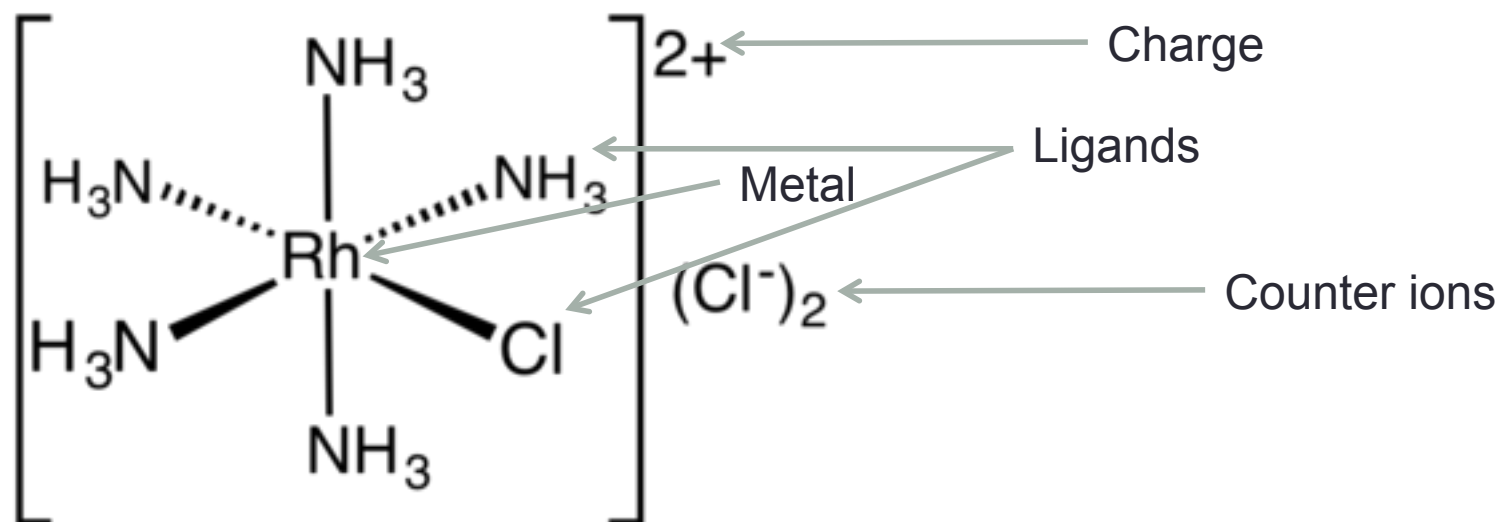


Some basic terminology

- This class will *mainly* focus on the chemistry of transition metals (d-block elements!)

3B	4B	5B	6B	7B	8	9	10	11	12
21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38
39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411
57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59
89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]

- Transition metal ions can form bonds with other species to form coordination complexes (think Lewis acid-Lewis base interaction)

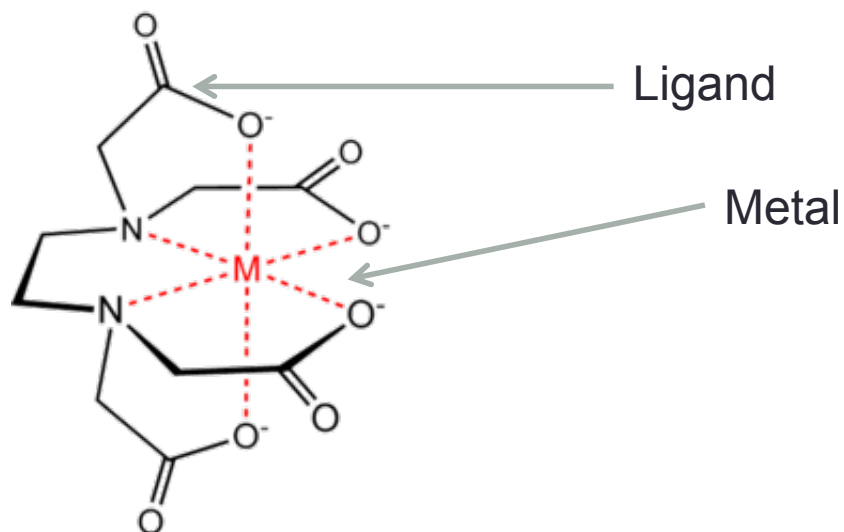


Some basic terminology

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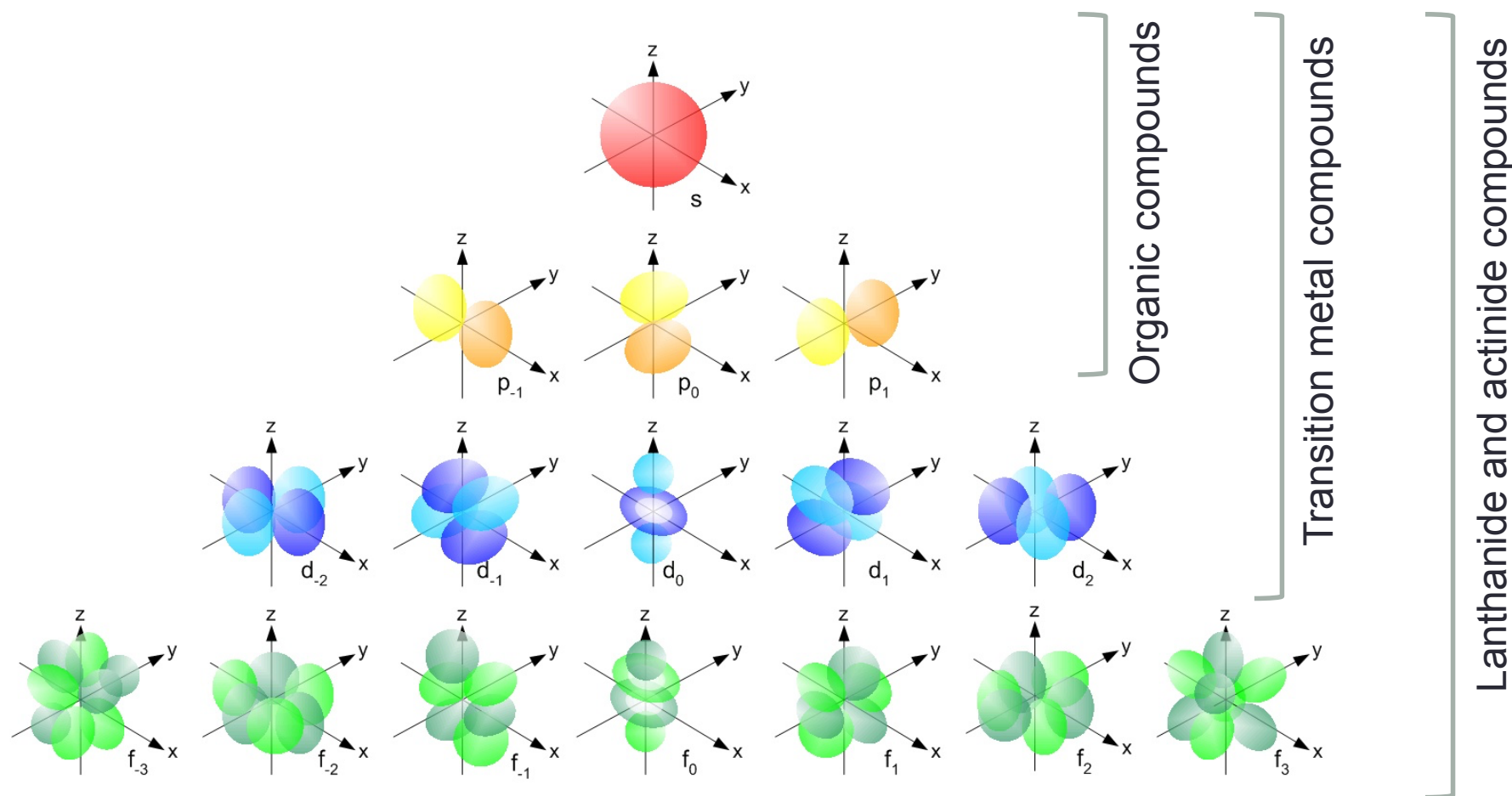
3B	4B	5B	6B	7B	8	9	10	11B	12B	
21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31
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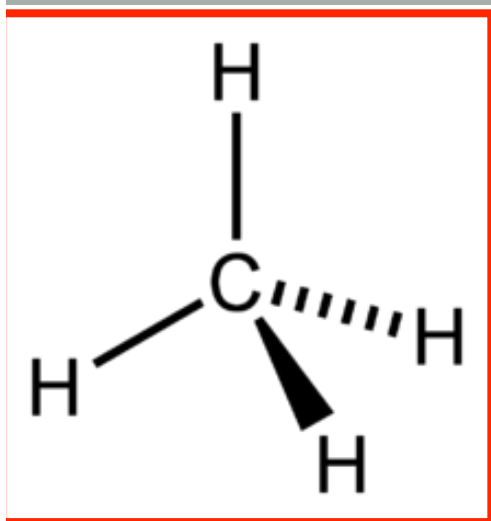
- Transition metal ions can form bonds with other species to form coordination complexes (think Lewis acid-Lewis base interaction)



COMPARISON OF INORGANIC AND ORGANIC CHEMISTRY

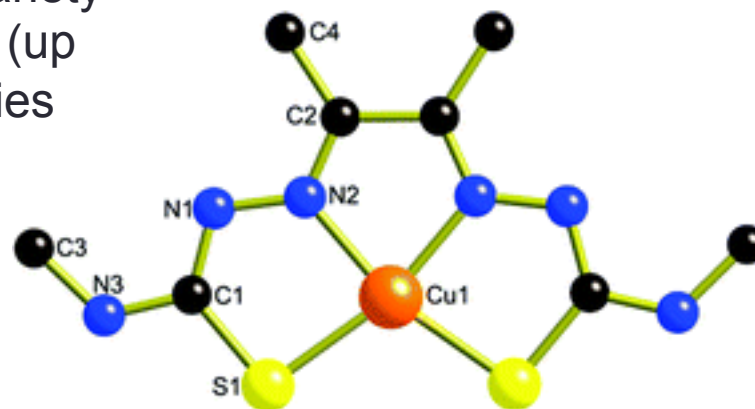
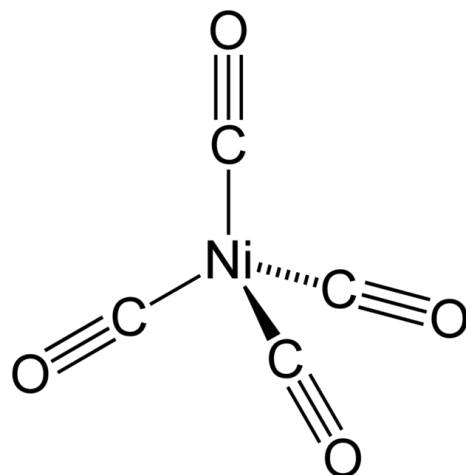




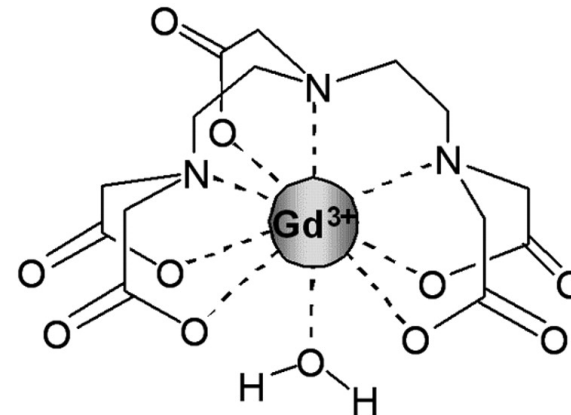
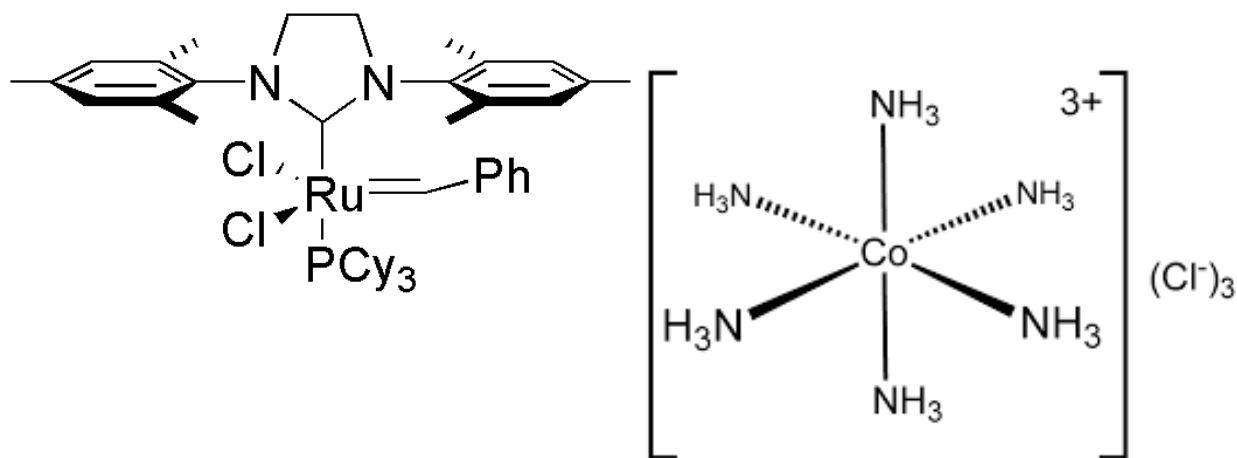


Organic chemistry:
C with max 4 bonds

Inorganic chemistry: a variety
of coordination numbers (up
to 9 or 10!) and geometries

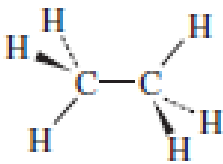
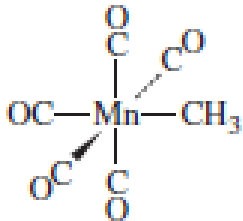
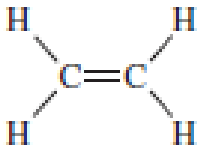
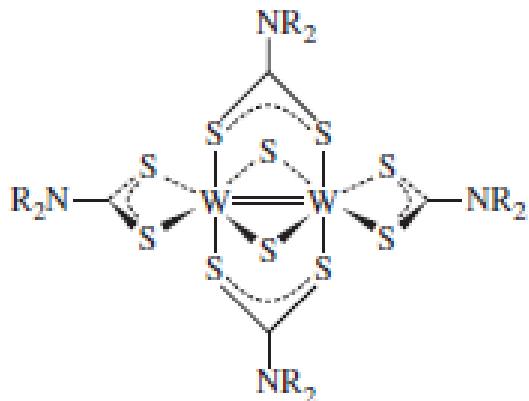
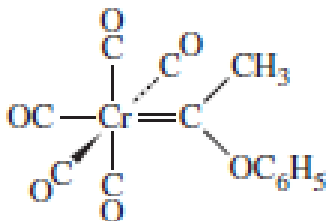
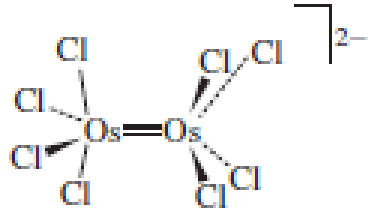
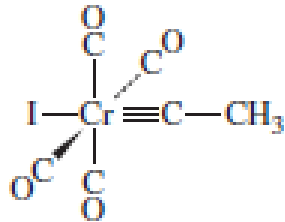
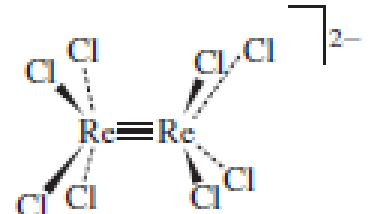


$\text{Cu}^{\text{I}}(\text{atsm})$



$\text{GdDTPA}(\text{H}_2\text{O})^{2-}$

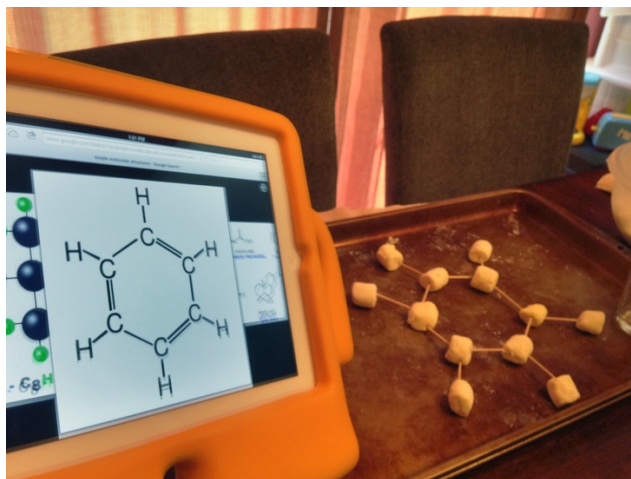


Organic	Inorganic		Organometallic
	$\text{F}-\text{F}$	$[\text{Hg}-\text{Hg}]^{2+}$	
	$\text{O}=\text{O}$		
$\text{H}-\text{C}\equiv\text{C}-\text{H}$	$\text{N}\equiv\text{N}$		
			



Three-dimensional perception helps!

- Use online tools (such as <http://symmetry.otterbein.edu/gallery/index.html>)
- Use molecular model kits!!!
<https://www.amazon.com/Molymod-MMS-009-Molecular-Inorganic-Chemistry/dp/B005RUTZ8Q>
- Or creative alternatives



INORGANIC CHEMISTRY IS EVERYWHERE

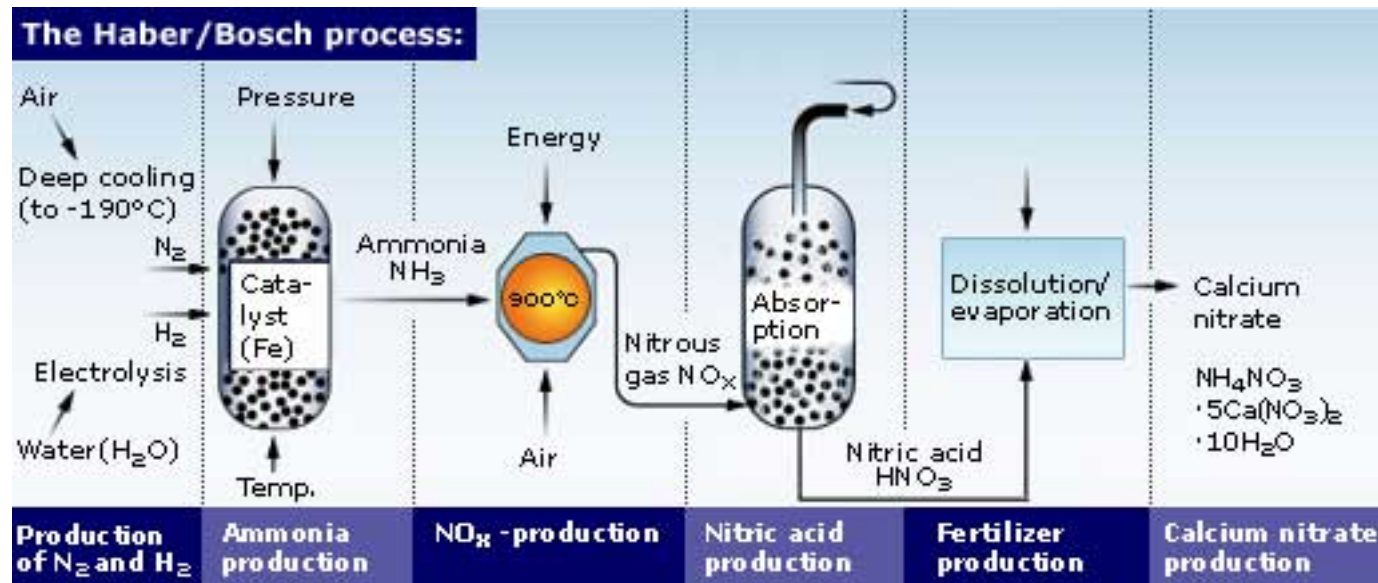


Haber Bosch Process

- Industrial process that uses an **Fe-based inorganic catalyst** to promote the following reaction:



- Revolutionized the production of ammonia for use in fertilizer
 - 500 million tons produced each year
 - Enabled rapid expansion of agricultural industry

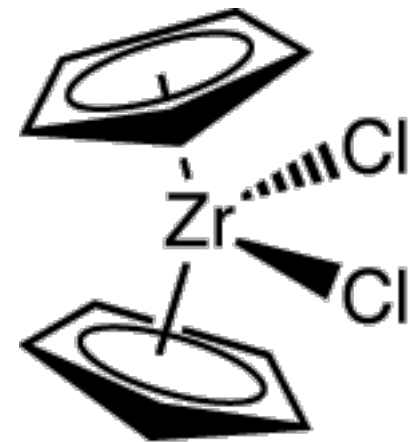
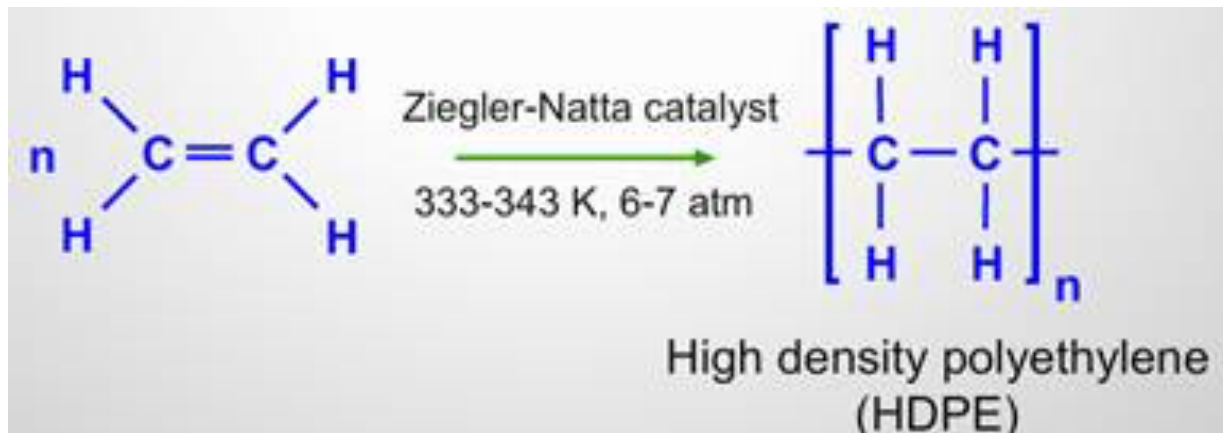


<https://haberbosch.wordpress.com/the-process/>



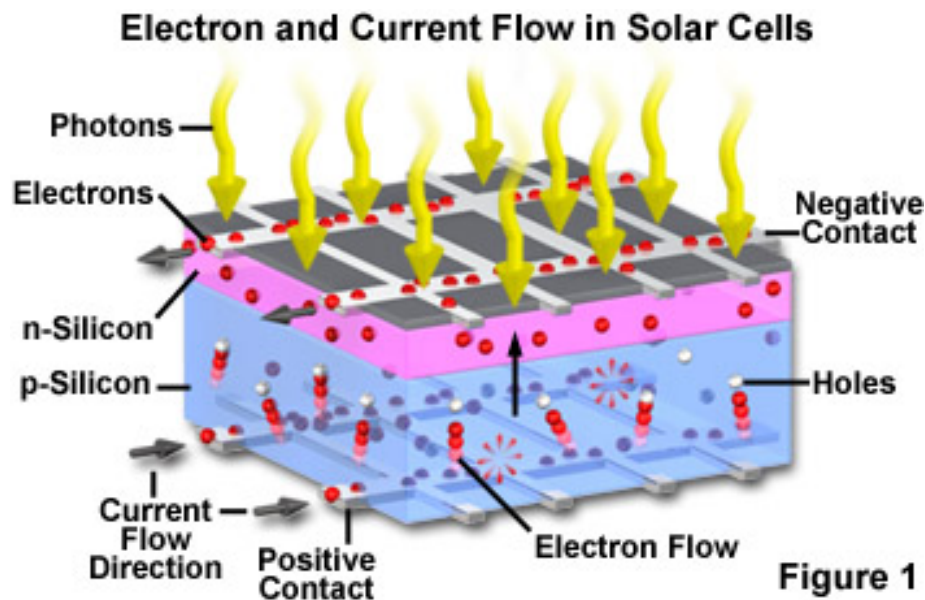
Ziegler Natta polymerization

- Industrial process for the production of polymers such as polyethylene
 - Heterogeneous catalysts based off of Ti
 - Homogeneous catalysts based off of complexes of Ti, Zr, Hf
- ~100 million metric tons of plastics produced using this and related processes
- 1963 Nobel Prize



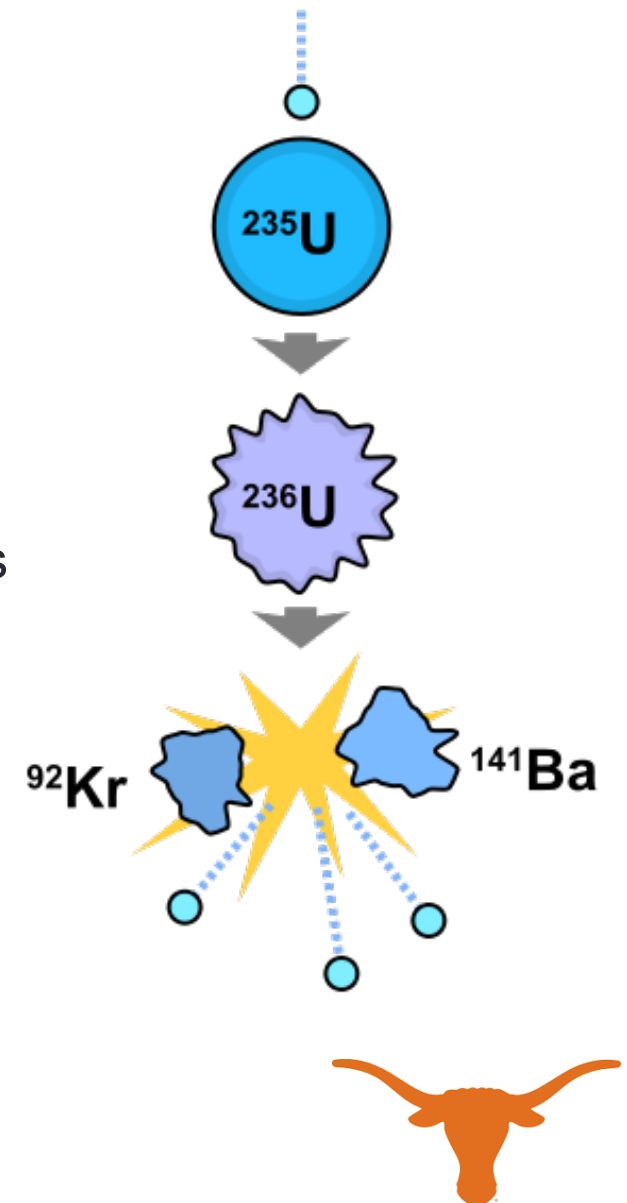
Solar cells

- Inorganic materials (e.g. silicon-based materials) are essential components of commercial solar cells



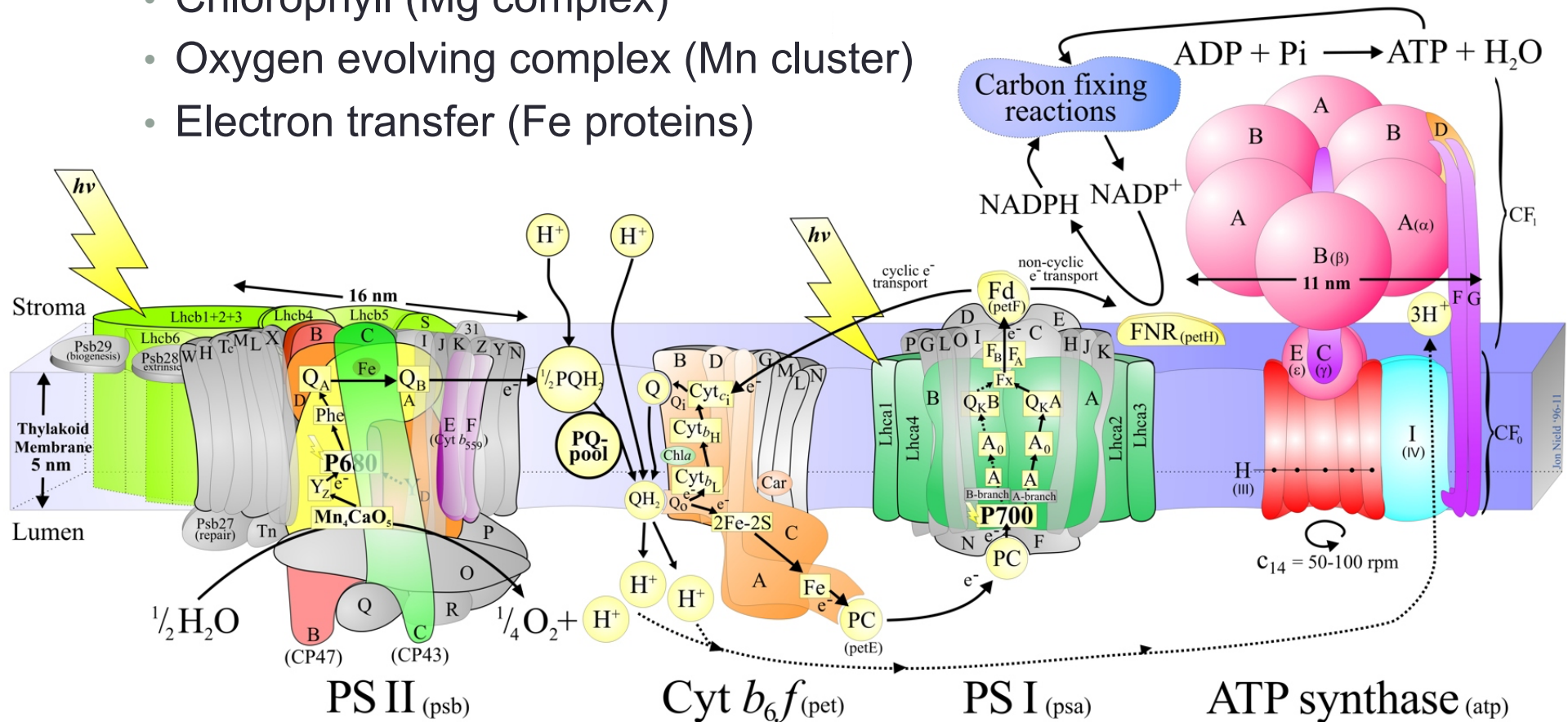
Nuclear energy

- Nuclear reactors convert the energy released by controlled nuclear fission into thermal energy for further conversion to mechanical or electrical forms.
- There are 450 nuclear power reactors that are used to generate electricity in about 30 countries around the world



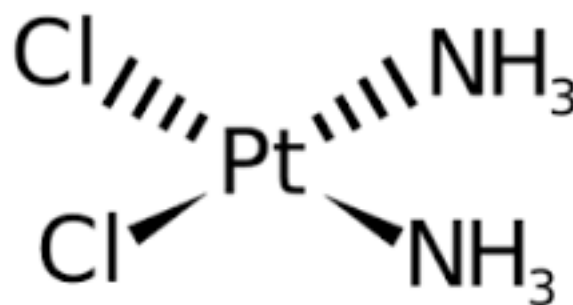
Photosynthesis

- A number of inorganic complexes are used during this important biological process
 - Chlorophyll (Mg complex)
 - Oxygen evolving complex (Mn cluster)
 - Electron transfer (Fe proteins)



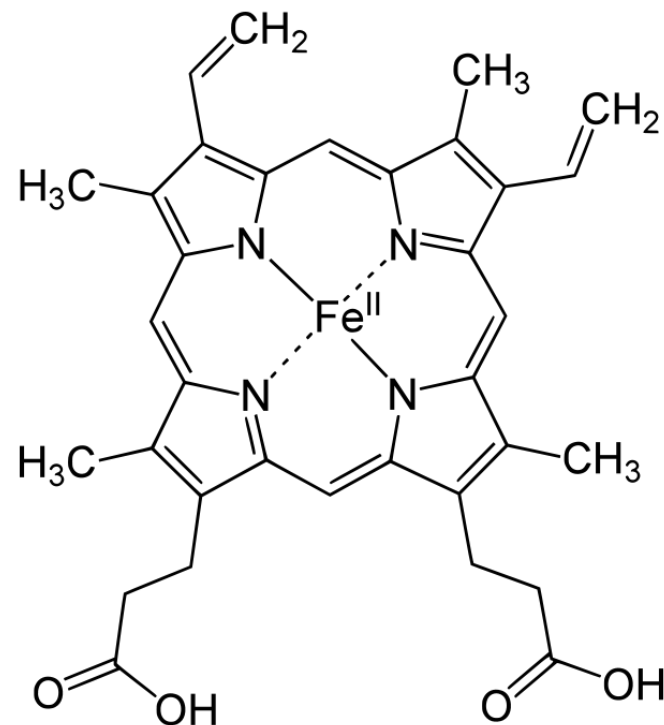
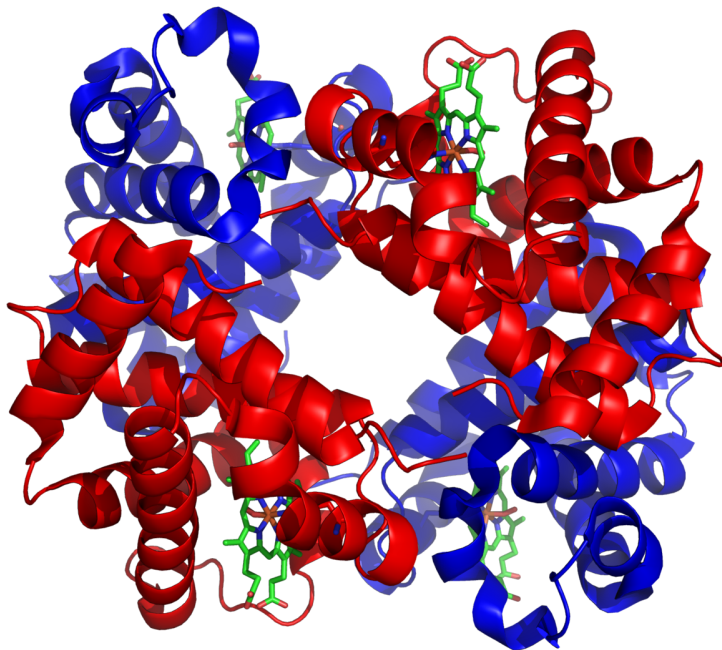
Cis-platin

- Chemotherapy used for the treatment of a variety of cancers including including sarcomas, some carcinomas (e.g., small cell lung cancer, and ovarian cancer), lymphomas, bladder cancer, cervical cancer...
- Improved cure rate of testicular cancer from 10% to 85%



Hemoglobin

- Metalloprotein that carries oxygen throughout the body
- At its core, an Fe ion bound by a heme ligand.
Interactions between Fe center and O₂ enable the transport of this gas



COURSE STRUCTURE

- 1) **Fundamentals of atomic and molecular structure**
Orbitals, Symmetry, Bonding
- 2) **Transition metal chemistry**
Structure, Reactivity, and Properties of transition metal complexes
- 3) **Applications of transition metal chemistry**
Organometallic chemistry/catalysis, bioinorganic chemistry



The next few weeks:

- Review of atomic orbitals, periodic trends, bonding (Chapter 2)
- Bonding basics, Lewis dot structures, VSEPR (Chapter 3)
- ...Symmetry and Group Theory (Chapter 4)

