

## Nov 25-Nov 29 Practice Problems

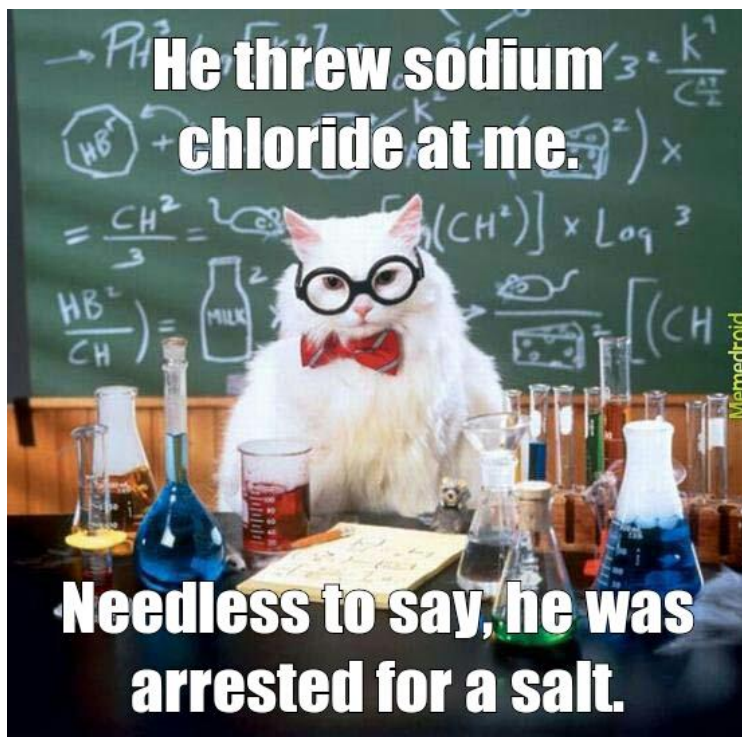
## Due dates:

This week you have Quiz 9

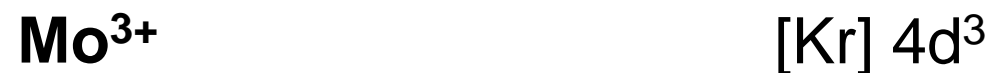
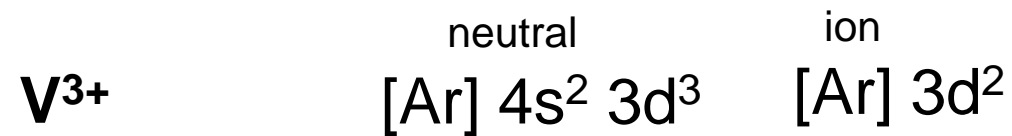
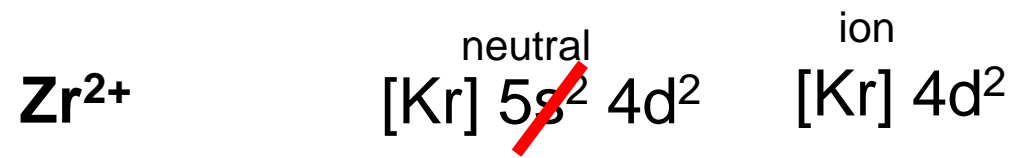
## Review end of the week

Mercury course evaluations! Please fill them out!

Office hours: Thursday, November 28 1:30 to 2:30 pm in Pulp and Paper 104



# Q1. Write the condensed electron configurations of the following :



Periodic table of the elements

																		18	
group	1*													13	14	15	16	17	18
1	2													5	6	7	8	9	10
1	2													5	6	7	8	9	10
3	4													13	14	15	16	17	18
3	4	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		

\*Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC). © Encyclopædia Britannica, Inc.

Q2. What is the oxidation state of Cr in  $[\text{Cr}(\text{OH})_6]^{3-}$ ? Is the chromium ion diamagnetic or paramagnetic? Would you expect this complex to be coloured?

Charge of complex = -3

$\text{Cr} + 6 \times (\text{OH}) = -3$

(OH) has a charge of -1

So

$\text{Cr} + 6(-1) = -3$

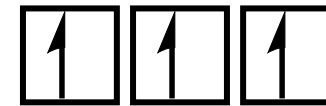
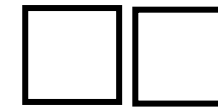
$\text{Cr} - 6 = -3$

$\text{Cr} = -3 + 6$

$\text{Cr} = +3$

Cr:  $[\text{Ar}] 4s^1 3d^5$

$\text{Cr}^{3+}$ :  $[\text{Ar}] 3d^3$



Paramagnetic (magnetic because unpaired electrons)

Coloured: electrons have a space in the d orbitals to move into

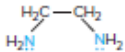
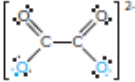
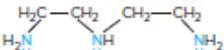
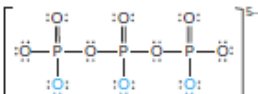
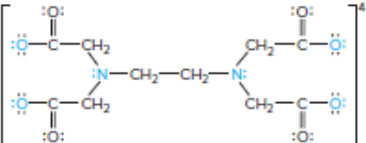
# Q3. Calculate the oxidation state of the transition metal in the coordination complexes. What is the coordination number?

Oxidation state	Coordination number
$[\text{CrCl}_2(\text{NH}_3)_4]^+ :$ $x + 2(-1) + 4(0) = +1$ $x - 2 = 1$ $x = 1 + 2 = 3 \text{ so } +3$	6

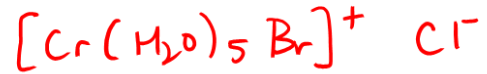
$[\text{Cr}(\text{OH})_2(\text{NH}_3)_4]^- :$ $x + 2(-1) + 4(0) = -1$ $x - 2 = -1$ $x = -1 + 2 = 1 \text{ so } +1$	6
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Anionic Ligand	Name
Cl <sup>-</sup> /I <sup>-</sup> /F <sup>-</sup> /Br <sup>-</sup>	Chloro/iodo/fluoro/bromo
NO <sub>2</sub> <sup>-</sup>	Nitro/nitrito
CN <sup>-</sup>	cyano
OH <sup>-</sup>	hydroxo
C <sub>2</sub> O <sub>4</sub> <sup>2-</sup>	Oxalato

Neutral Ligand	Name
NH <sub>3</sub>	ammine
H <sub>2</sub> O	aqua
NO	Nitrosyl
en	Ethylene diamine
CO	carbonyl

TABLE 24.6						Some Common Ligands in Coordination Compounds	
Ligand Type	Examples						
Monodentate	$\text{H}_2\ddot{\text{O}}:$ Water	$:\ddot{\text{F}}:^-$ Fluoride ion	$[:\text{C}\equiv\text{N}]^-$ Cyanide ion	Cyanide ion	$[\ddot{\text{O}}-\text{H}]^-$ Hydroxide ion		
	$:\text{NH}_3$ Ammonia	$:\ddot{\text{Cl}}:^-$ Chloride ion	$[:\text{S}=\text{C}=\ddot{\text{N}}:]^-$ Thiocyanate ion	Thiocyanate ion	$[\ddot{\text{O}}-\text{N}=\ddot{\text{O}}]^-$ Nitrite ion		
Bidentate	 Ethylenediamine (en)		 Oxalate ion				
	Polydentate	 Diethylenetriamine		 Triphosphate ion		 Ethylenediaminetetraacetate ion ( $\text{EDTA}^{4-}$ )	

Q4. What is the name of  $[\text{Cr}(\text{H}_2\text{O})_5\text{Br}]\text{Cl}$ ? What is the formula for barium hexacyanocobaltate(III)?



$\text{H}_2\text{O}$  = aqua

$\text{Br}^-$  = bromo

Penta = x 5

pentaaquabromo chromium

Overall positive charge so  
just "chromium" is good

What is the oxidation state of Cr???

Overall = +1                       $+1 = x + (-1)$   
Bromo ligand is -1             $1 + 1 = x$   
Aqua is neutral                 $x = +2$   
Cr = + 2 (or **II**)

pentaaquabromochromium(II)

Finally add the counter anion ( $\text{Cl}^-$ )

**pentaaquabromochromium(II) chloride**

barium  $\text{Ba}^{2+}$   
hexacyanocobaltate (III) ↓  
cyano =  $\text{CN}^-$

Six cyanos =  $6 \times (-1) = -6$

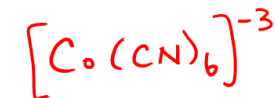
Cobalt oxidation number = +3

*So what is the overall charge of the whole coordination complex poly anion?*

Overall charge =  $+3 + 6(-1)$

Overall charge =  $+3 - 6$

Overall charge = -3



How do  $\text{Ba}^{2+}$  and  $[\text{Co}(\text{CN})_6]^{-3}$   
go together?



Q5. Which complex, in the following pairs, would you expect to absorb the higher energy visible light?  $\Delta E = h\nu = hc/\lambda$

Spectrochemical Series (of Ligands)

$I^-$ ,  $Cl^-$ ,  $F^-$ ,  $HO^-$ ,  $H_2O$ ,  $SCN^-$ ,  $NH_3$ , en,  $NO_2^-$ ,  $NC^-$ ,  $CO$

Increasing Field Strength 

a)  $[V(H_2O)_6]^{3+}$  or  $[V(NH_3)_6]^{3+}$

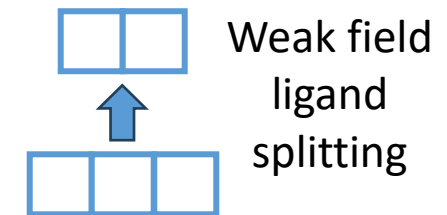
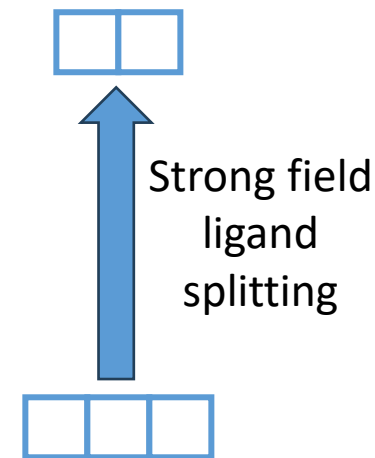
$[V(H_2O)_6]^{3+} \rightarrow H_2O$  ligand (weak field ligand)

$[V(NH_3)_6]^{3+} \rightarrow NH_3$  ligand (stronger field ligand)

b)  $[TiCl_6]^{3-}$  or  $[Ti(CO)_6]^{3+}$

$[TiCl_6]^{3-} \rightarrow Cl^-$  ligand is weaker field ligand

$[Ti(CO)_6]^{3+} \rightarrow CO$  ligand is a stronger field ligand



Q6. Compare the electron configurations of the two iron complexes below. Draw d-orbital energy diagrams to show splitting, predict the number of unpaired electrons, and identify each complex as “high spin” or “low spin”.  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$  vs.  $[\text{Fe}(\text{CO})_6]^{2+}$

**What is the oxidation number?**

(overall = + 2)

All ligands are neutral

So Fe = +2

Fe  $4s^2 3d^6$   
 $\text{Fe}^{2+} 3d^6$

**Spectrochemical Series (of Ligands)**

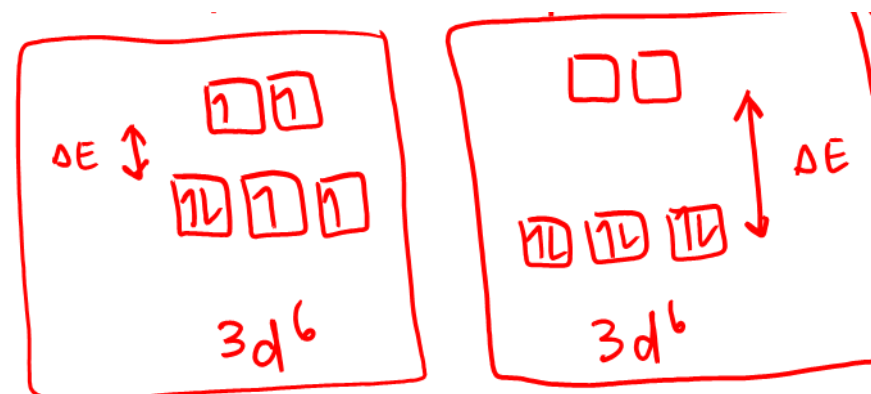
$\text{I}^-$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{HO}^-$ ,  $\text{H}_2\text{O}$ ,  $\text{SCN}^-$ ,  $\text{NH}_3$ , en,  $\text{NO}_2^-$ ,  $\text{NC}^-$ ,  $\text{CO}$

Increasing Field Strength

$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$  vs.  $[\text{Fe}(\text{CO})_6]^{2+}$

weaker  
field

stronger  
field



high spin

diamagnetic

low spin

# Slido Question

- What shape (geometry) are these coordination complexes?
- $[\text{CuCl}_2]^-$  and  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$

1) Linear and Tetrahedral

2) Octahedral and Tetrahedral

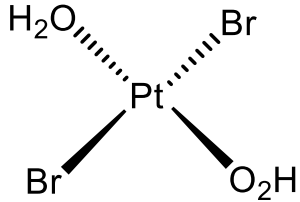
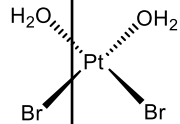
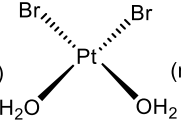
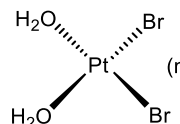
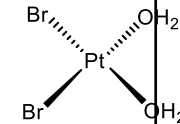
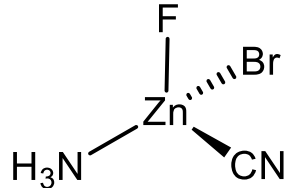
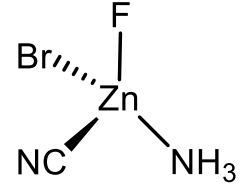
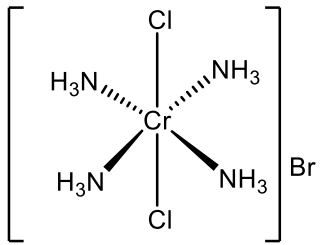
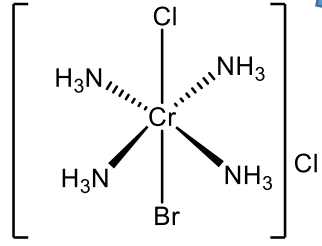
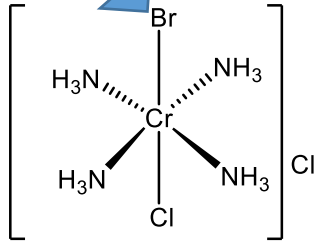
3) No geometry and Octahedral

4) Linear and Octahedral

5) Square Planar and Tetrahedral



Q7. **Draw** an example of the isomer listed for each of the complexes indicated.

Isomer Type	Complex	Your isomer
Geometric isomer		<div> <div>     </div> <div> <p>or (not and)</p> </div> <div>     </div> <div> <p>or (not and)</p> </div> </div>
Enantiomer		
Coordination isomer		<div>    <p>or (not and)</p>  </div>

These 4 are the same molecule (either option is accepted but not BOTH options)

These 2 are the same molecule (either option is accepted but not BOTH options)

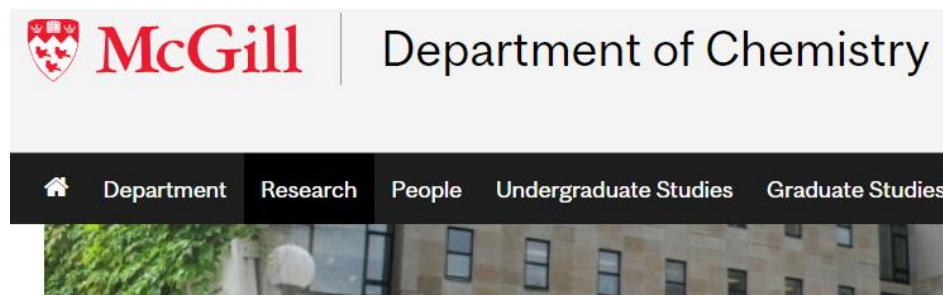
# My perspective on: *How to get into research?*

## Why bother?

- Research can be impactful
- Try new things NOW
- Reference letters

## How to find a research group:

- Figure out what you are interested in
  - Don't limit yourself to your exact program
  - <https://www.mcgill.ca/science/research/undergraduate-research/finding-opportunities>
- Read websites (at least a bit!)
- Send 2-5 short but *personalized* emails
  - Attach your CV and transcript
  - Write 3-4 sentences at most in email (personalized)



### Research themes

The Department research activity is structured around 5 themes illustrating the interdisciplinary nature of research in Chemistry. While each theme encompasses many of the classical areas of chemistry, they will also lead to a focused course of study.

The list of faculty members for each theme is provided below. Notice that many of the faculty are in multiple groups. Students in these groups choose their theme, based on the nature of their project. Each theme has a convener who you can speak with if you are looking for some general advice.

#### Analytical/ Environmental

Convener:  
[Mauzeroll, Janine](#)  
[Ariya, Parisa](#)  
[Barrett, Christopher](#)  
[Mauzeroll, Janine](#)  
[McKeague, Maureen](#)  
[Preston, Thomas](#)  
[Thibodeaux, Christopher](#)

#### Chemical Biology

Convener:  
[Aucclair, Karine](#)  
[Aucclair, Karine](#)  
[Bohle, Scott](#)  
[Caire da Silva, Lucas](#)  
[Cosa, Gonzalo](#)  
[Damha, Masad](#)  
[Harrington, Matthew](#)  
[Gleason, James](#)  
[Luedtke, Nathan](#)  
[Lumb, Jean-Philip](#)  
[Mauzeroll, Janine](#)  
[McKeague, Maureen](#)  
[Mittermaier, Tony](#)  
[Moltesier, Nicolas](#)  
[Steiman, Hanadi](#)  
[Thibodeaux, Christopher](#)  
[Tsantrizos, Youla](#)  
[Wiseman, Paul](#)

#### Chemical Physics

Convener:  
[Siwick, Brad](#)  
[Ariya, Parisa](#)  
[Barrett, Christopher](#)  
[Blum, Amy](#)  
[Kambhampati, Pat](#)  
[Khalullin, Rustam](#)  
[McCalla, Eric](#)  
[Mittermaier, Tony](#)  
[Preston, Thomas](#)  
[Reven, Linda](#)  
[Siwick, Brad](#)  
[Wiseman, Paul](#)

#### Materials Chemistry

Convener:  
[Harrington, Matthew](#)  
[Andrews, Mark](#)  
[Barrett, Christopher](#)  
[Blum, Amy](#)  
[Caire da Silva, Lucas](#)  
[Cosa, Gonzalo](#)  
[Harrington, Matthew](#)  
[Kakkar, Ashok](#)  
[Kambhampati, Pat](#)  
[Khalullin, Rustam](#)  
[Lennox, Bruce](#)  
[Lumb, Jean-Philip](#)  
[Moore, Audrey](#)  
[Perepichka, Dima](#)  
[Reven, Linda](#)  
[Steiman, Hanadi](#)  
[van de Ven, Theo](#)

#### Synthesis/Catalysis

Convener:  
[Arndtsen, Bruce](#)  
[Arndtsen, Bruce](#)  
[Aucclair, Karine](#)  
[Bohle, Scott](#)  
[Cosa, Gonzalo](#)  
[Damha, Masad](#)  
[Friedl, Tomislav](#)  
[Gleason, James](#)  
[Kakkar, Ashok](#)  
[Khalullin, Rustam](#)  
[Légaré, Marc-André](#)  
[Lennox, Bruce](#)  
[Li, C.J.](#)  
[Lumb, Jean-Philip](#)  
[Moore, Audrey](#)  
[Perepichka, Dima](#)  
[Steiman, Hanadi](#)  
[Thibodeaux, Christopher](#)  
[Tsantrizos, Youla](#)  
[van de Ven, Theo](#)

#### Green and Sustainable Chemistry

Convener:  
[Moore, Audrey](#)  
[Andrews, Mark](#)  
[Arndtsen, Bruce](#)  
[Aucclair, Karine](#)  
[Barrett, Christopher](#)  
[Bohle, Scott](#)  
[Caire da Silva, Lucas](#)  
[Cosa, Gonzalo](#)  
[Damha, Masad](#)  
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[Lumb, Jean-Philip](#)  
[McCalla, Eric](#)  
[McKeague, Maureen](#)  
[Moltesier, Nicolas](#)  
[Moore, Audrey](#)  
[Tsantrizos, Youla](#)

# How might the research take place?

## **Course credit (typical)**

- 1-semester 396 “research course” e.g., CHEM396, COMP 396, ENVR396, etc
- Many programs require an “honors project” in your last year  
<https://www.mcgill.ca/science/research/undergraduate-research/researchcourses>

## **Paid**

- Straight up research assistant: Rare in many departments
- Work-study (possible)
- Scholarship (external or internal)

## **Volunteer**

# How to get a professor to answer your email!

## #1 Suggest a path that allows you to be in the lab for 1 year (or more) so that the resources and time to train you also pay off for the lab/research

- Offer to apply for scholarships for working in the summer  
e.g., McGill SURA and NSERC USRA applications due end of January
- Offer to volunteer (if you can) or note if you are eligible for work study
- Attend group meetings
- #2 Meet in-person (naturally) in class, at a seminar/event (e.g, Soup & Science)

<https://www.mcgill.ca/science/research/undergraduate-research/soupscience>

### Notes:

- You *can* follow up once ~2-4 weeks later
- If they reply, reply fast
- You might have to contact dozens (think about supply/demand of department)
- **Start early (>1 semester in advanced)**