CHEM 222 Exam 4

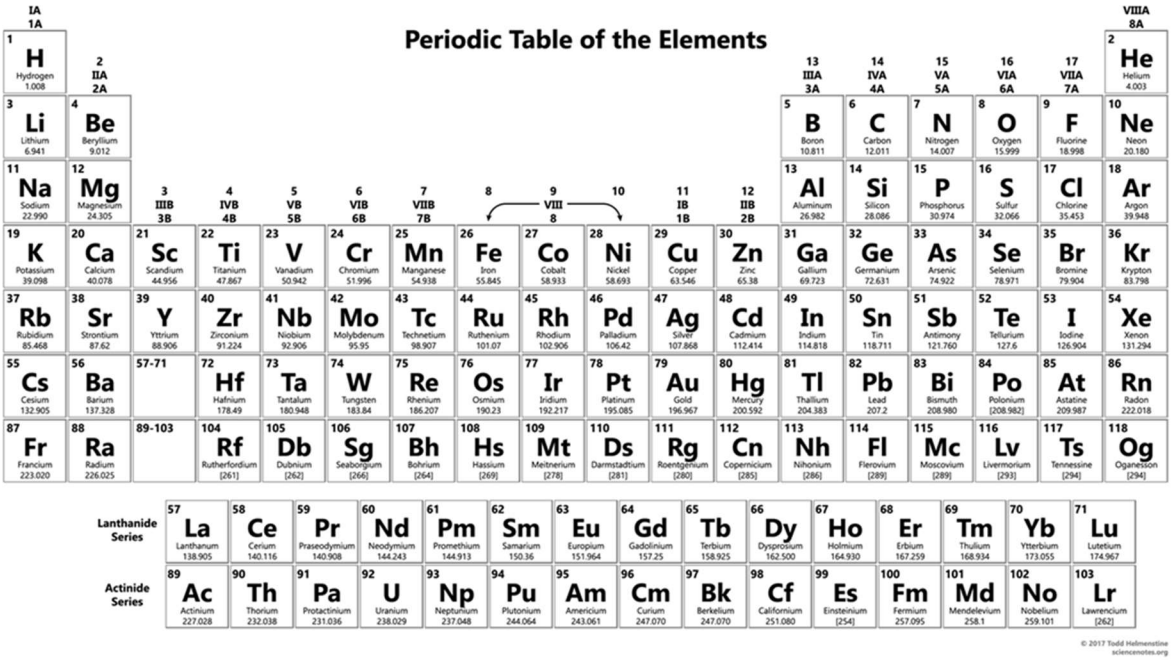
- You may begin the exam between 8:00 and 9:30 AM Wednesday, April 29, but you will have 90 minutes to complete the exam and upload scans of your work.
- You may use your book, notes, or online resources**, but you MAY NOT receive assistance from anyone other than Dr. Lamp.**
- Complete five (5) of the following problems on separate paper. There is no need to print out the exam. You must show your work to receive credit for problems requiring math. Report your answers with the appropriate number of significant figures. For discussion problems, be concise in your answers.
- Once you have completed the exam, scan your work as pdf and upload it to Blackboard.
- Submission of your work is your pledge that the exam was completed ethically! Unethical work will result in a grade of zero on the exam and the Student Affairs office will be notified.
- **Your exam materials must be uploaded by no more than 90 minutes after you begin the exam.** You may turn the exam in earlier if you wish.

Possibly Useful Information

$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$	$K_aK_b = K_w$	$F = 96485\ C\ mol^{-1}$
$E = E^o - \frac{2.303RT}{nF}\log Q = E^o - \frac{0.05916V}{n}\log Q$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$	$R = 8.31441\ Jmol^{-1}K^{-1}$
$E = \text{const.} + \beta\left(\frac{0.05916V}{n}\right)\log A_{ion}$	$\Delta G^o = -nFE^o = -RT\ln K$	$A = abc = \varepsilon bc = -\log T$

Values of α_{y4-} for EDTA at 20°C and μ = 0.10 M

pH	α_{y4-}	pH	α_{y4-}	pH	α_{y4-}
0	1.3×10^{-23}	5	3.7×10^{-7}	10	0.36
1	1.9×10^{-18}	6	2.3×10^{-5}	11	0.85
2	3.3×10^{-14}	7	5.0×10^{-4}	12	0.98
3	2.6×10^{-11}	8	5.6×10^{-3}	13	1.00
4	3.8×10^{-9}	9	5.4×10^{-2}	14	1.00



Complete five (5) of the following seven (7) problems. 16 points each

1. Consider the titration of 25.0 mL of 0.0255 M $Cd(NO_3)_2$ with 0.0120 M EDTA in a solution buffered at pH 9.00. (log K_f = 16.50 for the Cd^{2+}-EDTA complex)
   a. Calculate pCd^{2+} at <u>two</u> of the volumes below. (12 points)
      - At the equivalence point
      - At a volume half-way to the equivalence point
      - At a volume 11.0 mL after the equivalence point.
   b. Given that the fraction of the EDTA present as Y^{4-} does not reach its maximum until pH is over 12 or so, why would we choose to run the titration at pH 9.00 instead? (4 points)

2. In our magnesium determination in the laboratory, we added a solution made from ammonia and ammonium chloride to each sample prior to titrating with EDTA. Explain the two primary purposes served by the addition of this solution?

3. A 1.25 g sample of soil containing Cu^{2+} and Zn^{2+} and other nonmetals was digested in acid and diluted to a final volume of 50.00 mL. This solution was treated with 25.0 mL of 0.0452 M EDTA to bind all the metal. The excess <u>unreacted</u> EDTA required 12.4 mL of 0.0123 M Mg^{2+} for complete reaction. An excess of the reagent 2,3-dimercapto-1-propanol was then added *to <u>displace the EDTA from zinc only</u>*. Another 29.2 mL of Mg^{2+} were required for reaction with the liberated EDTA. Calculate the percent by weight of Cu^{2+} and percent by weight of Zn^{2+} in the original rock sample

4. Consider the electrochemical cell below:

   $$Pt(s)\,|\,Br_2(\ell)\,|\,HBr\,(aq, 0.0500\ M)\,||\,Cr(NO_3)_3\,(aq, 0.200\ M)\,|\,Cr(s)$$

   a. Calculate E_{cell} for the conditions given. (10 points)

Reaction (all species are aqueous unless noted)	**E^o (volts)**
$Br_2\,(aq) + 2e^- = 2Br^-$	+1.098
$Br_2\,(\ell) + 2e^- = 2Br^-$	+1.078
$NO_3^- + 4H^+ + 3e- = NO\,(g) + 2H_2O$	+0.955
$2H^+ + 2e^- = H_2(g)$	0.000
$Cr^{3+} + 3e^- = Cr(s)$	-0.740

   b. Is the reaction spontaneous in the direction written in part a? How do you know? (3 points)
   c. Is the reaction more favorable under standard conditions, or with the conditions given? How do you know? (3 points)

5. Given that E^o =+0.796 V for the reaction $Hg_2^{2+}(aq) + 2e^- \leftrightharpoons 2Hg(\ell)$ and K_{sp} =1.2x10^{-18} for $Hg_2Cl_2(s)$, calculate E for $Hg_2Cl_2(s) + 2e^- \leftrightharpoons Hg(\ell) + 2Cl^-(aq)$ under <u>standard conditions</u>.

6. You need to do a pH measurement and have a pH electrode, pH 4.00, 7.00, and 10.00 buffers, but **<u>no pH meter</u>**! You do, however, have access to a voltmeter capable of measuring potential differences at the millivolt level. Using these materials, describe how you could determine the pH of an unknown aqueous solution. Include a description of how you would collect the data and how you would use the data to find the pH of your unknown. *(hint: a pH electrode is an ISE for H^+)*

7. Consider a spectrophotometry experiment like we did for the iron lab. Address the following items.
   a. How is an appropriate wavelength chosen for an absorbance measurement? Why is this choice made? (4 points) *(limit your response to three sentences or less)*
   b. Why is a blank used in the measurement process? (4 points) *(limit your response to three sentences or less)*
   c. How is the concentration of an unknown solution determined? What data is collected and how is it treated? (8 points)