

Chem 113000-2 Spring 2022 Final Review

The following questions cover content from the entire quarter but in no way represent everything that you can be tested on. These questions should be supplemented with understanding of all homework problems, discussion worksheet problems, as well as the 3 midterms. Furthermore, the only additional material that should be needed to complete these questions is a calculator and a periodic table (in addition to the constants/values provided on this front page). While a formula sheet will be provided for your final, it is best to know as many of the equations.

Some useful constants:

1. K_{sp} for PbCl_2 is 1.17×10^{-5}
2. $R = 8.314 \text{ J/mol K}$
3. $F = 96485 \text{ C/mol e}$

Reduction	E° [V]
$\text{Fe}^{3+} \text{Fe}$	-0.036
$\text{Li}^+ \text{Li}$	-0.30
$\text{Mn}^{2+} \text{Mn}$	-1.17
$\text{Al}^{3+} \text{Al}$	-1.66
$\text{MnO}_2 \text{Mn}^{2+}$	1.21
$\text{Pb}^{2+} \text{Pb}$	-0.13
$\text{Hg}^{2+} \text{Hg}$	0.85
$\text{Cu}^{2+} \text{Cu}$	0.34
$\text{Rh}^{3+} \text{Rh}$	0.800

1. For the following questions, select the *one* correct answer for each multiple choice questions.
- (a) Which of these types of decay results in a change in the mass number of the parent nuclide?
- A) α decay
B) β decay
C) γ decay
D) Electron capture decay
E) Positron emission decay
- (b) Which of the following pairs of name and formula is matched correctly?
- A) Beryllium bisulfite, $\text{Be}(\text{HSO}_4)_2$
B) Silver peroxide, Ag_2O_2
C) Dialuminum trioxide, Al_2O_3
D) Phosphorus sulfide, P_2S_3
E) Ammonium bicarbonate, NH_3HCO_3
- (c) Which of the following combinations of aqueous solutions would result in no reaction?
- A) sodium sulfide + calcium nitrate
B) lithium sulfate + barium acetate
C) silver nitrate + sodium phosphate
D) barium chloride + lead acetate
E) zinc nitrate + lithium hydroxide
- (d) Which of the following is true of an unsaturated solution?
- A) $Q > K_{sp}$
B) $Q < K_{sp}$
C) $Q = K_{sp}$
D) $Q = K_{sp}^{-1}$
E) $Q = K_{sp}^2$
- (e) Which among the following choices is most likely to be oxidized?
- A) Cu (s)
B) Li (s)
C) Zn (s)
D) Ag (s)
E) Fe (s)
- (f) In a galvanic cell setup for the reaction $\text{Cr (s)} + 3 \text{Ag}^+ \text{(aq)} \rightleftharpoons \text{Cr}^{3+} \text{(aq)} + 3 \text{Ag (s)}$, the overall cell potential will be less than the expected value under standard conditions if:
- A) The salt bridge is made narrower.
B) The concentration of Ag^+ is made larger.
C) The concentration of Cr^{3+} is made larger.
D) The silver electrode is made larger.
E) The chromium electrode is made larger.

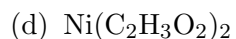
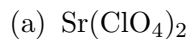
(g) Which lattice structure is not based on the closed pack arrangement of anions:

- A) CsCl B) ZnS (blende) C) LiCl D) CaF₂

(h) Which is the most likely to adopt a square planar coordination:

- A) [AuCl₄]⁻ B) [Fe(CN)₄]²⁻ C) [NiCl₄]²⁻ D) [Fe(H₂O)₄]³⁺

2. Write the correct name for each of the following compounds.



3. Consider crystal Ge.

(a) Assuming that Ge assumes a structure similar to sphalerite, describe its structure in terms of close-packing.

(b) Given that the density of Ge is 5.323 g/cm³, determine the Ge-Ge bond length.

4. Answer the following questions about the element tellurium, Te.

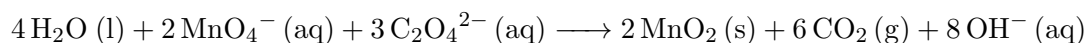
- (a) Samples of natural tellurium contain eight different stable isotopes of the element. In terms of atomic structure, explain what these isotopes have in common and how they differ.

- (b) Would you expect an object made of pure tellurium to be magnetic? Why or why not?

- (c) Write a balanced nuclear reaction that represents that most likely first *natural* decay pathway for a nuclide of Te-120.

- (d) How would you expect the electron affinity of tellurium to compare with that of sulfur and with that of xenon? Explain your comparisons.

5. Consider the following redox reaction:



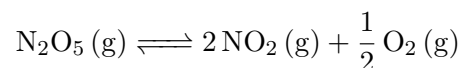
- (a) In the spaces above the reaction, assign proper *per atom* oxidation numbers to each atom.
- (b) In this reaction, which type of atom is being reduced?

- (c) In this reaction, which ion, compound, or species is the reducing agent?

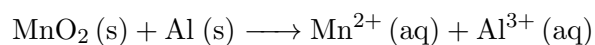
- (d) Briefly explain what happens at the atomic level in this reaction that makes it a redox reaction.

6. How many grams of $\text{Pb}(\text{NO}_3)_2$ could you add to a 120 mL solution before any precipitate forms if that solution already contains 2.0×10^{-3} M NaCl and 5.0×10^{-4} M PbCl_2 ? (Assume no volume change upon the addition of solid.)

7. The rate constant for the first-order decomposition of the reaction below is $7.48 \times 10^{-3} \text{ s}^{-1}$ at a given temperature. How long (in seconds) will it take for the *total* pressure in the system to rise to 0.200 atm if the initial system contains only 0.100 atm of N_2O_5 (g)?

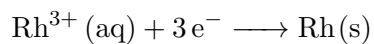


8. Consider the following questions related to this redox reaction at 298K.

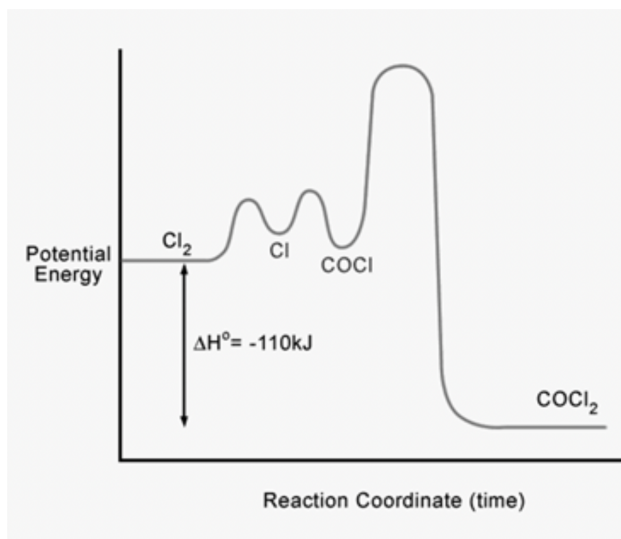


- (a) Balance the above redox reaction, assuming an acidic solution.
- (b) The reaction above initially contains 10.0 g $\text{Al}(\text{NO}_3)_3 (\text{aq})$ and excess $\text{MnO}_2 (\text{s})$ in a total volume of 2.2 L at an initial pH of 1.2. Once the reaction has reached equilibrium the $[\text{Mn}^{2+}]$ is 0.0012 M. Calculate the overall cell potential for this reaction under these conditions.

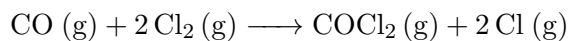
9. (a) An electrolytic cell has an iron anode in a solution of iron (III) nitrate. How must you construct the other half cell if the overall voltage required to power the cell is -0.094 V under standard conditions?
- (b) You decide to use a Cu/Cu^{2+} concentration cell as a battery to power the reaction in part (a). The cathode half-cell has been set up for you and is composed of a solid piece of copper in $5.0\text{ M Cu}(\text{NO}_3)_2(\text{aq})$. How many grams of $\text{Cu}(\text{NO}_3)_2$ must be added to 0.75 L of water in the other half-cell to produce a sufficient overall voltage to power the reaction in part (a)?
10. Your special someone has requested a ring made purely of rhodium, but rhodium is expensive and you're on a budget. Being a crafty chemist, you decide to use a plating cell to plate a cheap silver ring with rhodium (No one will notice the difference right?). Your special someone is coming over to your place in exactly 2 hours. If you start right now, will you have enough time to plate 7.0 g of rhodium onto the ring using a current of 2.3 A in your plating cell?



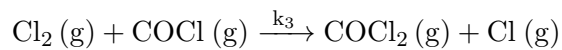
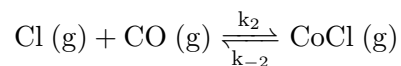
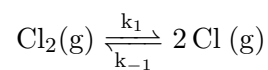
11. Given the following mechanism and energy diagram, determine the **rate** for the overall reaction if you start with 0.25 M CO and 0.30 M Cl₂ ($k_{overall} = 11 \text{ M}^{-3/2}\text{s}^{-1}$).



Overall Reaction:



Proposed Mechanism:



12. A student investigated the reaction $\text{heat} + \mathbf{A} + \mathbf{B} + 2\mathbf{C} \longrightarrow \mathbf{D}$ for 200 seconds per trial at 25°C , with the data collected shown in the table provided on the right.

Trial	$[\mathbf{A}]_i$ (M)	$[\mathbf{B}]_i$ (M)	$[\mathbf{C}]_i$ (M)	Initial Rate (M/s)
1	0.30	0.05	0.05	6.0×10^{-5}
2	0.30	0.10	0.05	6.0×10^{-5}
3	0.40	0.05	0.20	3.2×10^{-4}
4	0.40	0.05	0.05	8.0×10^{-5}

Given this information, along with the fact that the activation energy for the slowest step of this reaction's mechanism is 40 kJ/mol , calculate the initial rate for this reaction if it were run at 40°C using the same initial concentrations as in trial 3.

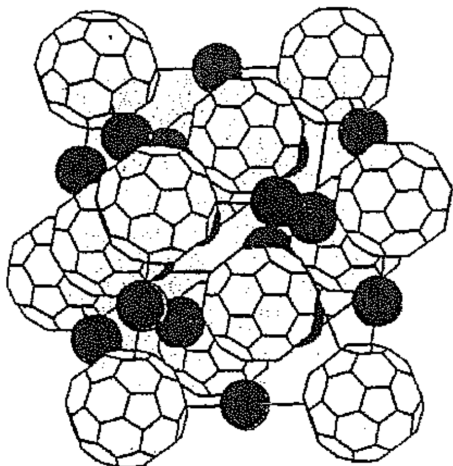
13. Consider the structure of hexanitrocuprate (II).

(a) What is the chemical formula for this structure?

(b) Draw all linkage isomers.

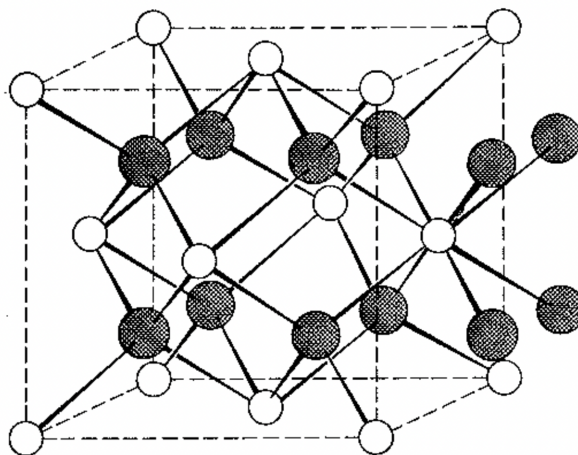
(c) Assuming that the crystal field is the same in both isomers, draw the crystal field diagram and give the CFSE.

14. Answer the following questions using the picture below of a salt of Buckminsterfullerene (C_{60} , soccer ball) that contains potassium (black spheres).



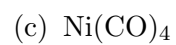
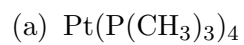
- (a) Describe the structure and determine the number of atoms in the unit cell.
- (b) What is the mass of a single unit cell?
- (c) Explain what would happen if Rubidium is substituted for potassium to the lattice parameter.

15. The unit cell shown below is for a compound Ba_xI_y .



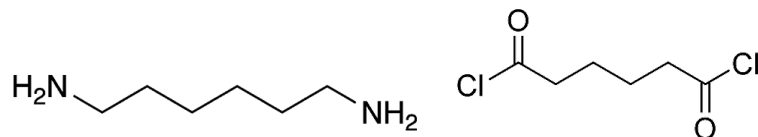
- (a) Determine the chemical formula (ie the lowest whole number values for x and y).
- (b) How many Ba ions, I ions, and formula units are in this unit cell?
- (c) Describe the placement of Ba ions and I ions.

16. Determine the structure and magnetic properties of the following compounds.

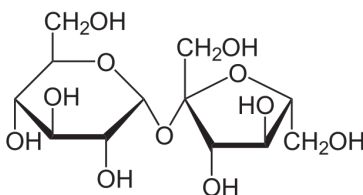


(e) Which of the above four complexes is most likely to appear green? Please explain why.

17. In lecture, 6,6 nylon was shown to be produced using hexamethylenediamine and adipic acid. However, in practice 6,6 nylon is made via polymerization of hexamethylenediamine (left) and adipoyl chloride (right) since adipoyl chloride is more reactive. That is, the polymerization will occur more rapidly and at lower temperatures.



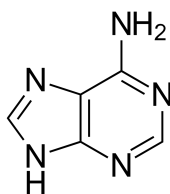
- (a) What type of polymerization will occur?
- (b) What are the products if 1 hexamethylenediamine and 1 adipoyl chloride react?
- (c) Draw the repeat unit that results from the polymerization of adipoyl chloride and hexamethylenediamine.
18. Sucrose, ie table sugar, shown below is made up of a molecule of glucose (left) and fructose (right).



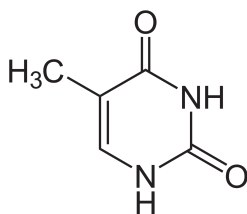
- (a) What type of bond connects fructose and glucose?
- (b) What type of carbohydrate is fructose?
- (c) What type of carbohydrate is glucose?
- (d) What type of carbohydrate is sucrose?

19. What is the currently accepted hypothesis for why proteins fold?

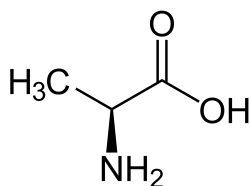
20. Lets consider some of the building blocks of life. For each of the following molecules, determine if they will rotate plane-polarized light or not.



(a) Adenine



(b) Thymine



(c) Alanine

If you recall, alanine is an amino acid, and in general the left most methyl group is replaced by other substituents to form other types of amino acids. It should hence be noted that nature has a preferred handedness and it is not exactly known why. For example, the DNA helix is a right-handed helix whereas amino acids are left-handed, despite left-handed helix's and right-handed amino acids being possible to make.

If you have gotten this far in the worksheet, then I want to thank you for a great year! I hope you learned something useful this year during our time together, whether that be a chemistry related topic or not. I wish you all the best on the final, and for the rest of your college career. And, as always, don't hesitate to reach out if you ever need anything in the future!

Lab TAs in a nutshell:

