

## Chem 130 – Third Exam

Name \_\_\_\_\_

On the following pages you will find questions covering various topics ranging from the structure of solid-state materials, the chemistry of acid-base and oxidation-reduction reactions, and metal-ligand complexes. Read each question carefully and think about how to approach the problem before you put pen or pencil to paper. If you aren't sure how to start a question, move on to another problem; often working on a new question will suggest an approach to that more troublesome problem. For problems requiring a written response, be sure that your answer is written in complete sentences and that it directly and clearly answers the question. Partial credit is willingly given on all problems so be sure to answer all questions!

Question 1 \_\_\_\_/20

Question 5 \_\_\_\_/8

Question 2 \_\_\_\_/12

Question 6 \_\_\_\_/8

Question 3 \_\_\_\_/12

Question 7 \_\_\_\_/8

Question 4 \_\_\_\_/12

Question 8 \_\_\_\_/20

Total \_\_\_\_\_

Potentially useful equations and constants:

$$c = \lambda\nu \quad E = h\nu \quad KE = h\nu - BE \quad \frac{1}{\lambda} = 1.09737 \times 10^{-2} \text{ nm} \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad V = \frac{kq_1q_2}{d}$$

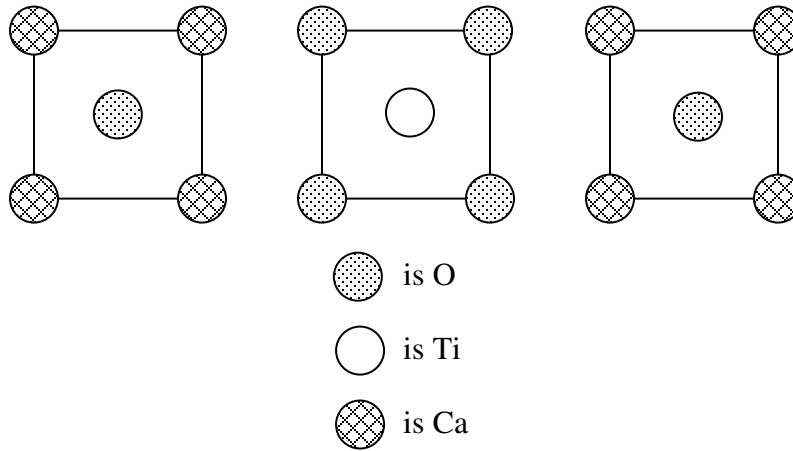
$$FC_a = V_a - N_a - \frac{B_a}{2} \quad \delta_a = V_a - N_a - B_a \left( \frac{EN_a}{EN_a + EN_b} \right)$$

$$OX_a = V_a - N_a - B_a \times (0 \text{ if least EN; } 1 \text{ if most EN})$$

$$c = 2.998 \times 10^8 \text{ m/s} \quad h = 6.626 \times 10^{-34} \text{ Js} \quad N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$K_a \times K_b = K_w \text{ for conjugate acid/base pair}$$

**Question 1.** Shown below are three cross-sections through the unit cell of calcium titanate, also known as the mineral perovskite.



What is the formula (the stoichiometry) for calcium titanate based on this unit cell? Be sure to show clearly how you arrived at this formula by specifically labeling each atom with its contribution to the unit cell.

The titanium ion can be considered to sit in two types of holes – a hole in a lattice defined by calcium ions and a hole in a lattice defined by oxygen ions. For each case, state the type of hole in which the titanium ion sits and what percentage of these holes are filled.

for a lattice of calcium ions

for a lattice of oxygen ions

To how many oxygen ions is each calcium coordinated? Briefly explain how you arrived at your answer.

**Question 2.** Arrange the following solutions (all of equal concentration) from the most acidic to the most basic. You do not need  $K_a$  or  $K_b$  values to determine the order, so such values are not provided. Hint – you might find Lewis structures of some help.



	most acidic				most basic
	1	2	3	4	5
solution					

In the space below explain how you made your decisions, limiting your answer to 4-6 sentences. Feel free to illustrate your answer with appropriate figures or diagrams, but be sure to refer to the figures or diagrams in your written response.

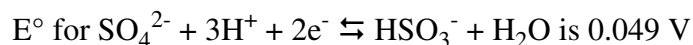
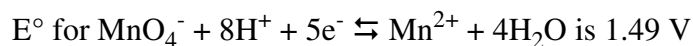
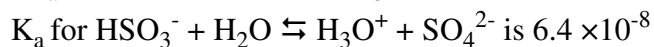
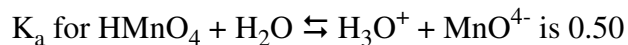
**Question 3.** Consider the following weak acids:  $H_2O$ , HF, and  $H_2S$

In two or three sentences each, explain why HF is a stronger acid than  $H_2O$

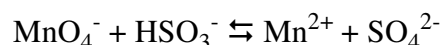
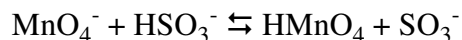
and why  $H_2O$  is a weaker acid than  $H_2S$ .

Hydrogen sulfide,  $H_2S$ , has two acidic protons, but water,  $H_2O$ , has only one. Briefly explain, in one or two sentences, why the second proton in water is not acidic.

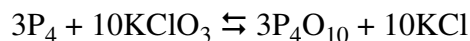
**Question 4.** A few years ago a spill of potassium permanganate,  $\text{KMnO}_4$ , occurred in Greencastle, which eventually was traced to the local Culligan distributor. Dave Roberts, volunteer fire fighter and DePauw Storeroom Manager, treated the spill by adding sodium bisulfate,  $\text{NaHSO}_3$ . Given the following pieces of information



decide which of the following unbalanced reactions was responsible for cleaning up the spill (circle your choice). Briefly explain, in 2-4 sentences, how you made your decision.

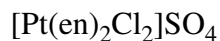


**Question 5.** Some of the earliest matches consisted of white phosphorous,  $\text{P}_4$ , and potassium chlorate,  $\text{KClO}_3$ , glued to the end of wooden sticks. When “struck”, the following oxidation-reduction reaction occurred:



Identify the compound that is the oxidizing agent in this reaction and state the specific change in oxidation state that is occurring.

**Question 6.** Name the following two coordination compounds (en = ethylenediamine)



**Question 7.** When cis and trans isomers exist, the name of a coordination compound includes information to specify the geometry. Given this information, draw the following complex ion *cis-diammine-trans-diaquadicyanocobalt(III)*.

**Question 8.** Thiocyanate,  $\text{SCN}^-$ , is a ligand that can bind either through the sulfur or the nitrogen. In the space below, draw all possible isomers (geometric and optical) for the complex ion  $\text{Fe}(\text{SCN})_2\text{Cl}_4^{4-}$ . Be careful to draw each unique isomer only once. *Use the next page to draw and evaluate structures and then transfer to the space below only those structures that you wish me to examine.*

**Use this space to draw and evaluate structures for problem 8.**