SHOW YOUR WORK. NO WORK, NO CREDIT

Carefully and completely explain your reasoning on all problems! Sometimes this simply means showing calculation steps in a logical sequence, writing down enough steps to clearly show your thought processes. Other times it means writing a few words of explanation, and sometimes both will be required.

INCLUDE LABELS AND PROPER NUMBER OF SIG FIGS
UP TO 75% OF THE POINTS GIVEN FOR CORRECT SET UP, INCLUDING LABELS.

WORK ON ONE SIDE OF PAGE ONLY WITH NAME OR INITIALS ON EACH PAGE
If you wish to save a tree, use the back side of printer paper from the recycle bin in the computer labs.

1. (5 pts each) Name the following compounds: SnSO₃, NO₂, PbS

2. (5 pts each) Write formulas for the following compounds: mercury (I) phosphide, carbon monoxide, strontium nitrite

3. (6 pts) What is the oxidation number on Mo in (NH₄)₂Mo₂O₇?

4. (6 pts) How many decimal places should you show when expressing lengths measured with the ruler shown below?

5. (3 pts each) On the outline of the periodic table attached, locate the following by drawing a box or boxes around the section and writing in the label:
   a. alkali metals   b. inner transition metals
   c. liquid elements  d. diatomic gases

6. For ⁷⁸Pt⁶⁺
   a. (6 pts) What is the electron configuration for this ion?
   b. (6 pts) Is this ion paramagnetic or diamagnetic?
   c. (6 pts) Based on our discussions in class, would you expect this charge to be a stable charge for Pt?
7. (10 pts) Draw the molecular orbital correlation diagram for Cl₂. Since bonding interactions occur primarily with valence shell electrons, you need to show only the correlations for the outer shell orbitals.

8. (3 pts each) For CO₃²⁻ and XeF₄:
   a. Draw the Lewis structures including any resonance structures.
   b. What is the shape of each molecule?
   c. What are the approximate bond angles in each? (for shapes distorted by lone pairs use the terms “slightly greater than” or “slightly less than” in specifying the bond angles)
   d. Is each polar or nonpolar?
   e. What is the hybridization for each?

9. Photoelectric effect: in an experiment you determined the longest wavelength of light that can eject an electron from cadmium is 290.0 nm.
   a. (14 pts) Calculate work function (Φ) for Cd from this data.
   b. (6 pts) Look up the actual value (textbook, CRC handbook, etc.) and calculate the percent error for a). Cite the reference where you found the actual value.

10. Three non-equivalent resonance structures can be written for the cyanate ion (CNO⁻¹):
    
    \[
    \begin{align*}
    \text{[I}O\bar{C}\equiv\text{N]}^{-1} & \rightleftharpoons \text{[O}\equiv\text{C}\bar{\text{N}}]^{-1} & \rightleftharpoons \text{[O}=C\equiv\text{N]}^{-1} \\
    \end{align*}
    \]
    
    a. (6 pts) Which of the three is expected to be the most important contributor (most stable)?
    b. (6 pts) How many σ bonds are there in the first structure shown?
    c. (6 pts) How many π bonds are there in the first structure shown?

11. (10 pts) Xe and Ne are both in the inert gas family and are expected to have similar chemical properties. Xenon reacts with fluorine to form XeF₄, a reasonably stable compound that you drew a Lewis structure for in a previous problem. However, a similar compound for Ne has never been isolated; Ne does not react with fluorine at all. Explain this difference in chemical behavior for these two inert gases.

12. (10 pts) In lab the class is running a series of reactions that use several potentially hazardous chemicals. Groups are working on the lab benches and are scattered throughout the lab (typical situation for our lab). Your group has finished the experiment earlier than those groups around you. Is it OK for your group to remove your safety goggles to work on calculations at your lab desk while the others finish the lab? Explain your reasoning.

13. (20 pts) HF is used industrially to make synthetic cryolite (Na₃AlF₆) which is used in the production of aluminum. The unbalanced reaction is:
    \[
    \text{NaAlO}_2 + \text{NaOH} + \text{HF} \rightarrow \text{Na}_3\text{AlF}_6 + \text{H}_2\text{O}
    \]
    When 164 kg NaAlO₂ was mixed with 350 L of 29M HF in an excess of NaOH, 500 mole of cryolite was actually recovered. What is the percent yield for this reaction?

14. (10 pts) The relationship between circumference and diameter of a circle is given by \( C = \pi D \) which is in the form of an equation for a straight line \( y = mx + b \). The graph on the right is a plot of circumference vs. diameter measurements for a number of circles. The solid line is the trendline through this data and the equation at the top represents the straight line that best fits the data. What is the experimental value for \( \pi \) from this data?
I PLEDGE ON MY HONOR THAT DURING THE EXAM I HAVE NEITHER GIVEN NOR RECEIVED
ASSISTANCE NOR HAVE I SEEN ANY DISHONEST WORK.

Signed __________________________________________________________________________

If you feel you can’t sign this, contact the instructor (e-mail or in person)

Due November 19, 5 pm in GSC 254 (DEW’s Office)

WORK ON YOUR OWN, NOT IN GROUPS
This exam is to be an individual effort. You may use any books, notes, calculators, and/or computers. You may consult with the instructor, but I may not answer all your questions.

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1. (14 pts) In the ozone layer, the partial pressure of O₃ is 1.2 x 10⁻⁶ torr. If the density of O₃ in the ozone layer is 4.105 x 10⁻⁹ g/L, what is the temperature of the ozone layer?

2. (5 pts each) SiH₄ and PH₃ are both gases at room temperature.
   a. If sealed tubes of each were slowly cooled, which one would condense (liquify) first? Explain your reasoning.
   b. Which would you expect to be more soluble in CCl₄ (l)? Explain your reasoning.

3. (6 pts each) Identify each reaction as acid-base, redox, precipitation, or none of the three. Some reactions may fit more than one category. Explain your reasoning on each.
   a. Mg + HCl ! MgCl₂ + H₂
   b. Ba(NO₃)₂ + H₂SO₄ ! BaSO₄ + HNO₃

4. (15 pts) Write and balance the net ionic reaction:
   \[ KCr(SO₄)₂ + H₂CO₃ \rightarrow Cr₂(CO₃)₃ + K₂SO₄ + H₂SO₄ \]

5. (15 pts) Balance this redox reaction that takes place in acidic solution:
   \[ IO₄⁻¹ + Mn^{2⁺} \rightarrow I⁺ + MnO₄⁻¹ \]
6. When methyl tert-butyl ether (MTBE), \( \text{C}_5\text{H}_{12}\text{O} \), a gasoline additive used to boost octane ratings, is burned in an excess of oxygen, the \( \Delta H^\circ_{\text{rxn}} \) is -3369 kJ/mole MTBE.
   a. (5 pts) Write a balanced reaction for the combustion of MTBE.
   b. (10 pts) Will combustion of 1.00 g of MTBE generate enough heat to bring 100.00 g of water from room temperature (25.00°C) to a boil? Explain your reasoning.

7. When an aqueous solution of copper (II) (light blue color) is mixed with aqueous ammonia (colorless), an equilibrium is formed between these reactants and an aqueous complex ion (dark blue color) as shown by the reaction:
   \[
   \text{Cu}^{2+} + 4 \text{NH}_3 = \text{Cu(NH}_3)_4^{2+}
   \]
   a. (5 pts) Write the equilibrium constant expression for this reaction.
   b. (10 pts) Calculate \( \Delta G^\circ \) for this reaction.
   c. (5 pts) Is this reaction under standard conditions spontaneous as written? Explain your reasoning.
   d. (10 pts) Calculate \( K_{eq} \) (the value) for this reaction.
   e. (7 pts) If HCl is added to the equilibrium mixture, will the solution color get darker, lighter, or stay the same? Assume the total volume of solution does not change. Explain your reasoning.
   f. (7 pts) If this equilibrium mixture were sealed in a flask and then argon pumped in until the pressure in the flask doubles, would the solution color get darker, lighter, or stay the same? Explain your reasoning.

8. (15 pts) What is the pH of 1.00 x 10\(^{-4}\) M barium hydroxide?

9. (10 pts) While working in the lab you accidentally drop a 250 mL reagent bottle of 6 M NaOH and it shatters on the floor. You make a quick check of yourself and find no evidence of splashes or cuts. What should you do next?

10. (15 pts) Acid-base titrations like the ones you did in lab are used to monitor quality of antacid tablets. The Rolaids plant is producing antacid tablets that are supposed to have between 334 mg and 338 mg of \( \text{NaAl(OH}_2\text{CO}_3} \). A quality control lab tech tested lot 4859 to see if it met specs. Five tablets were selected at random from the lot, dissolved in water and titrated with 0.2500 M HCl. The balanced titration reaction is:
   \[
   \text{NaAl(OH}_2\text{CO}_3} + 4 \text{HCl} \rightarrow \text{NaCl} + \text{AlCl}_3 + 3 \text{H}_2\text{O} + \text{CO}_2
   \]
   The average volume of HCl used was 37.41 mL/tablet. Was lot 4859 acceptable for packaging and sale? Show your work or explain your reasoning.

11. (10 pts) OxyClean Bleach lists the following as ingredients sodium percarbonate (\( \text{Na}_2\text{CO}_4 \)) and sodium carbonate (\( \text{Na}_2\text{CO}_3 \)). Is an aqueous solution of OxyClean expected to be acidic, basic, or neutral? Explain your reasoning.

12. (15 pts) Both \( \text{CaCl}_2 \) and \( \text{Na}_3\text{PO}_4 \) can be used to melt ice and snow on streets. If both cost $1/kg, which salt would be more economical to use to keep ice from forming on streets? Explain your reasoning.

13. (10 pts) \( \text{SO}_3 \) is a nonpolar molecule so it is not expected to dissolve in water. However, it is very soluble in water and the resulting solution is very acidic. Explain this strange behavior.