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)

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 CREDIT 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: NH₄ClO₂, SnBr₄, NO₂.

2. (5 pts each) Write formulas for the following compounds: lead acetate, mercury (I) sulfite, dibromine pentoxide.

3. (6 pts) What is the oxidation number on W in K₂WO₄?

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

5. (15 pts) Consider this modification of the experiment you did in lab. A balloon was
inflated with 320 g of methane (CH₄). Then 640 g of oxygen was added to the balloon
and the two gases were allowed to mix thoroughly. The balloon was then attached to
a valve and metal tube as shown in the figure at the right. Note this is similar to a
Bunsen burner with a valve for adjusting the flow of gas, but without
an inlet for
additional air. The burner was set up under an evaporating dish just like the one you
used in lab. The valve was opened and the burner ignited. Did the gas mixture in the
balloon burn cleanly (complete combustion of the fuel) or did it blacken the bottom of
the dish (incomplete combustion of the fuel)? Explain your reasoning; show your work
on any calculations used.

6. (15 pts) The Permissible Exposure Limit (PEL) for bromine gas set by the Occupational Safety and Health Administration
(OSHA) is 0.7 mg/m³ in air. How many atoms of bromine are there in 1 µL of air at this concentration?

7. (7 pts each) Draw Lewis structures including any resonance structures for SF₄ and NO₃⁻.
8. (10 pts) In class we drew the Lewis structure for XeO₂ as structure A below. However, most chemists would draw structure B as a better representation of the compound even though the octet rule is violated. Using formal charges, explain why structure B is preferred.

\[
\begin{align*}
\text{I} & \equiv \text{Xe} \equiv \text{O} \\
\text{A} & \equiv \text{O} \equiv \text{Xe} \equiv \text{O} \\
\text{B} & \equiv \text{O} \equiv \text{Xe} \equiv \text{O}
\end{align*}
\]

9. For each of the Lewis structures shown below, give:
   a. (2 pts each) the shape of the molecule,
   b. (1 pt each) the approximate bond angles expected, and
   c. (2 pt each) determine if the molecule is polar or non-polar.
   Remember to explain your reasoning.

\[
\begin{align*}
\text{AsH}_3 & \\
\text{O}=\text{C}
\end{align*}
\]

10. Based on its electron configuration, would you expect \( _{26}^{26}\text{Fe}^{+6} \) to be
   a. (7 pts) a stable charge for iron?
   b. (7 pts) paramagnetic or diamagnetic?

11. (15 pts) The experimentally determined first ionization energy for Al is 578 kJ/mole. What is the longest wavelength of electromagnetic radiation that can eject an electron from Al?

12. (15 pts) We mentioned in class that one area of research is in using reverse osmosis to make drinking water out of sea water. Sea water is about 10% dissolved salts and has a density of about 1.1 g/mL. Assuming that the dissolved salt is all MgBr₂ and that we have a membrane that allows only water to cross, what is the minimum pressure a pump must be able to apply to purify sea water at 25.0°C?

13. On a nice, sunny day when the air pressure was 700.0 torr and the temperature was 27°C, an industrious student decided to try a couple of experiments using a bicycle tire pump. She first raised the plunger on a pump to its highest position and then screwed a pressure gauge into the end of the hose forming a closed system (no air leaks). She then adjusted the gauge so it read atmospheric pressure (700.0 torr).
   a. (7 pts) She then pushed the plunger half way in and allowed the pump temperature to return to 27°C. What pressure did she read on the pressure gauge? (Remember, there are no air leaks).
   b. (7 pts) Just after she read that pressure, the phone rang. She dropped the pump and ran to the phone. When she dropped the pump, the plunger returned to its fully raised position. During the next 30 minutes while she was visiting with a friend, the pump sat in the hot sun. When she returned, the temperature of the pump was 54°C. What pressure did the gauge read when she returned?

14. (15 pts) This problem expects you to predict the behavior, not just look up the numbers and compare. Would you expect \( \text{PCl}_3 \) or \( \text{SO}_3 \) to be more soluble in liquid \( \text{CO}_2 \)? Explain your reasoning.

15. (5 pts) Nitrogen and phosphorus are in the same group, so you would expect them to exhibit similar chemical properties. \( \text{NCl}_3 \), \( \text{PCl}_3 \), and \( \text{PCl}_5 \) are all stable compounds that are easily synthesized in the lab. However, \( \text{NCl}_5 \) has never been synthesized or observed. Why would phosphorus form two compounds with chlorine, but nitrogen form only \( \text{NCl}_3 \), and not \( \text{NCl}_5 \)?

16. (6 pts) Why is it NOT a good idea to store coats and book bags on the lab benches in lab?
1. (12 pts) The research and development lab of a sporting goods company has determined that the reactants and products for three different reactions are safe to use in commercial products. The $\Delta H$ for Reaction 1 is -48.1 kJ/mole, for Reaction 2 is 0.0 kJ/mole, and for Reaction 3 is +15.3 kJ/mole. Which of the three reactions would be the best candidate for producing a cold-pack for treating sports injuries? Explain your reasoning.

2. (15 pts) 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. $\text{NH}_3 (g) + \text{HCl (g)} \rightarrow \text{NH}_4\text{Cl (s)}$
   b. $\text{Al} + \text{H}_2\text{O} \rightarrow \text{Al(OH)_3} + \text{H}_2$

3. In 1 M sulfuric acid, potassium dichromate reacts with ethylene glycol to form oxalic acid and chromium (III) sulfate. The molecular reaction is:
   \[ \text{H}_2\text{SO}_4 + \text{K}_2\text{Cr}_2\text{O}_7 + \text{C}_2\text{H}_6\text{O}_2 \rightarrow \text{H}_2\text{C}_2\text{O}_4 + \text{Cr}_2(\text{SO}_4)_3 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O} \]
   a. (12 pts) Write the net ionic reaction.
   b. (12 pts) Balance the net ionic reaction - note it is a redox reaction.

4. (15 pts) What is the specific heat of titanium if it takes 89.7 J to raise the temperature of a 33.0 g block of Ti 5.20 degrees?

5. (11 pts) The class has just finished the Bunsen burner lab. A couple hours after lab you realize that you left your lab manual in the lab. When you get back to the lab to pick it up, you see that no one is in the lab and you detect an odor of natural gas in the lab. What should you do?

6. (15 pts) Would you expect $\text{NH}_4\text{F}$ to be acidic, basic, or neutral in water? In your explanation, include the reactions that justify your prediction.

7. (12 pts) NO$_2$ and SO$_3$ are blamed for acid rain. Explain how these compounds, which contain no hydrogen, can make rain acidic.

8. (15 pts) Explain why each of the following is or is not a buffer.
   a. 1 mole of HCl and 0.75 mole of NaCl dissolved in 100 mL of water.
   b. 1.5 mole of Na$_2$SO$_4$ and 1 mole of Na$_2$SO$_3$ dissolved in 100 mL of water.
   c. 1 mole of HNO$_2$ and 0.25 mole of NaOH dissolved in 100 mL water.
   d. 1 mole HNO$_3$ and 0.50 mole HNO$_2$ dissolved in 100 mL water.

9. (15 pts) What concentration of barium hydroxide is required to produce an aqueous solution with a pH of 9.38?

10. (12 pts) In the lab you are directed to titrate 100.0 mL of an NH$_3$ solution with 0.2500 M HCl. Which would be the best indicator for the titration: methyl red, bromthymol blue, or phenolphthalein? Explain your reasoning. You may wish to consult the table of indicators on page 65 of your lab manual.

11. (15 pts) What is the pH of a solution produced by dissolving 5.000 g chlorous acid and 5.000 g sodium chlorite in 100.0 mL water?

12. (15 pts) One step in the commercial production of nitric acid is the oxidation of ammonia with oxygen, an exothermic process. The reaction is:
   \[ \text{NH}_3 (g) + \text{O}_2 (g) \rightarrow \text{NO}_2 (g) + \text{H}_2\text{O} \]
   where the physical state of water depends on the operating conditions. Based on LeChatelier’s Principle, what reaction
conditions should be employed to maximize the yield of this reaction? Explain your reasoning.

13. I⁻ is slowly added to a solution containing $1.00 \times 10^{-3}$ M Ag⁺ and $1.00 \times 10^{-3}$ M Pb²⁺. Assuming that addition of the iodide does not change the volume of the solution,
   a. (12 pts) what is the concentration of iodide when the lead just starts to precipitate?
   b. (12 pts) What is the concentration of silver at this point (when the lead just starts to precipitate)?