SHOW YOUR WORK. NO WORK, NO CREDIT

INCLUDE LABELS AND PROPER NUMBER OF SIG Figs
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CONSTANTS AND EQUATIONS YOU MAY NEED

\[ N_0 = 6.022 \times 10^{23} \text{ particle/mole} \]
\[ 1 \text{ mL} = 1 \text{ cm}^3 \]
\[ D = \frac{m}{V} \]
\[ c = \frac{\lambda}{\nu} \]
\[ E = h \nu \]
\[ c = 2.998 \times 10^8 \text{ m/s} \]
\[ h = 6.626 \times 10^{-34} \text{ J s} \]
\[ \frac{\text{J}}{\text{photon}} \]

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Signed __________________________________________________________________________

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Multiple choice - circle the correct answer.

1. (1 pt) What symbol (metric system prefix) is used to represent the factor 10^{-9}?
   a) n  b) µ  c) M  d) m

2. (1 pt) Which of the following elements has chemical properties similar to oxygen?
   a) sulfur  b) nitrogen  c) fluorine  d) hydrogen

3. (1 pt) How many significant figures are there in the answer to (8.881 x 2.100) + 0.590 = ?
   a) one  b) two  c) three  d) four

4. (1 pt) Which of the following elements is a gas at room temperature?
   a) iron  b) argon  c) bromine  d) sodium

5. (1 pt) Round off 00500306 to three significant figures.
   a) 5.00 x 10^5  b) 5.00 x 10^6  c) 501  d) 500,000

6. (1 pt) Identify the element designated by Q in \( ^{33}_{16}Q \).
   a) As  b) S  c) O  d) Cl

7. (1 pt) The solid compound, \( \text{Na}_3\text{PO}_4 \), contains
   a) \( \text{Na}_3\text{PO}_4 \) molecules.  b) \( \text{Na}^+, \text{P}^{5-}, \) and \( \text{O}^{2-} \) ions.  c) \( \text{Na}^+ \) and \( \text{PO}_4^{3-} \) ions.  d) \( \text{Na}_3^+ \) and \( \text{PO}_4^{4+} \) ions.

8. (4 pts) If \( \text{SnO}_3^{3-} \) is called stannate, what is the formula for hypostannite? Explain your reasoning.

9. (3 pts) Write the formula of the compound that results when \( \text{BiO}^{3+} \) combines with \( \text{IO}_4^{-1} \).
10. (3 pts each) Name the following compounds.
   a. SO₂ ________________________________
   b. Fe₃(PO₃)₂ ________________________________

11. (3 pts each) Write the formula for each of the following compounds.
   a. dichlorine pentoxide ________________________________
   b. mercury (II) perchlorate ________________________________

12. (2 pts) How many decimal places should there be in measurements made with the ruler shown below?

   ![Ruler Image]

13. (1 pt each) Give an example for each of the following:
   semimetal __________________________
   liquid element at room temperature __________________________
   alkaline earth metal __________________________

14. (3 pts) What is the oxidation number (charge) on C in H₂C₂O₄?  Explain your reasoning.

15. (8 pts) How many atoms of nitrogen are there in 15.3 mg of Ba(NO₃)₂?

16. (8 pts) What is the mass percent of oxygen in KMnO₄?

17. (8 pts) The balanced reaction of muriatic acid with lime is
   \[ 2 \text{HCl} + \text{CaO} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} \]
   If 15.00 mL of 0.2000 M HCl is reacted with 0.1000 g of CaO, which will be the limiting reagent?  Explain your reasoning.

18. (6 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.

19. (8 pts) Infrared radiation used by a particular TV remote has a wavelength of 15.2 µm.  What is the frequency of that radiation?

20. (8 pts) One band of ultraviolet light that is filtered out by the ozone layer has a frequency of 1.0 x 10¹⁴ s⁻¹.  What is the energy of one mole of photons of that light?

21. The first method used to obtain iron from its ores was to react the oxide ore with charcoal (carbon) in the reaction:
   \[ \text{Fe}_2\text{O}_3 + C \rightarrow \text{Fe} + \text{CO}_2 \]
   a. (6 pts) Balance the reaction.
   b. (8 pts) The extent of reaction (yield) depends on the operating conditions.  In one batch 2.14 kmoles of Fe₂O₃ was mixed with an excess of carbon.  What is the expected yield (theoretical yield) of Fe for this reaction?
   c. (6 pts) If 1.3 kmole of iron was actually recovered from this reaction, what is the percent yield for the reaction?

Chemistry 120
March 18, 2005

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<td>soluble</td>
<td>none</td>
</tr>
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<td>silver, lead, mercury(I)</td>
</tr>
<tr>
<td>Sulfates</td>
<td>soluble</td>
<td>strontium, barium, lead</td>
</tr>
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</tr>
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</table>

| AX_2 | linear |
| AX_3 | trigonal planar |
| AX_4 | tetrahedral |
| AX_5 | trigonal bipyramid |
| AX_6 | octahedral |

| AX_2E | see saw |
| AX_3E | square pyramid |
| AX_4E | square planar |
| AX_4E2 | linear |
| AX_5E | linear |

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Circle the correct answer:

1. (2 pts) How many cations are there in 0.015 mole of sodium phosphate?
   a) \((0.150)(6.022\times10^{23})\) cations
   b) \((3)(0.150)(6.022\times10^{23})\) cations
   c) \((2)(0.150)(6.022\times10^{23})\) cations
   d) \((4)(0.150)(6.022\times10^{23})\) cations

2. (2 pts) Which of the following have their valence electrons in the same shell?
   a) B, As, Si
   b) He, Ne, F
   c) K, As, Br
   d) N, As, Bi

3. (2 pts) Of the following elements, which has the highest electronegativity?
   a) As
   b) Sc
   c) P
   d) S

4. (2 pts) Which electron configuration for \( \text{In} \) shown below represents an excited state?
   a) \([\text{Kr}]\ 5s^2\ 4d^{11}\)
   b) \([\text{Kr}]\ 5s^3\ 4d^{10}\)
   c) \([\text{Kr}]\ 5s^2\ 4d^{10}\ 5p^1\)
   d) \([\text{Kr}]\ 5s^2\ 4d^6\ 6f^2\)

5. (2 pts) List the elements Na, Ca, Rb, Cl, He in order of decreasing first ionization energy (highest \( E_{i1} \) first).
   a) He > Na > Cl > Ca > Rb
   b) He > Na > Ca > Cl > Rb
   c) He > Cl > Ca > Na > Rb
   d) Rb > Ca > Cl > Na > He

6. (2 pts) The following diagram represents the reaction of \( \text{A}_2 \) (white spheres) with \( \text{B}_2 \) (black spheres). How many moles of product can be produced from the reaction of 1.0 mol of \( \text{A}_2 \) and 1.0 mol of \( \text{B}_2 \)?
7. (2 pts) The spheres below represent atoms of Li, Be, B, and F (not necessarily in that order). Which one of these spheres represents an atom of F?

\[
\begin{array}{cccc}
\text{r = 72 pm} & \text{r = 83 pm} & \text{r = 112 pm} & \text{r = 152 pm} \\
(a) & (b) & (c) & (d)
\end{array}
\]

8. (2 pts) Which Lewis Structure below cannot exist as a real molecule?

\[
\begin{array}{cccc}
\text{H} & \text{H} & \text{H} & \text{H} \\
\text{N} & \text{N} & \text{P} & \text{P} \\
\text{H} & \text{H} & \text{H} & \text{H} \\
\text{H} & \text{H} & \text{H} & \text{H}
\end{array}
\]

9. (3 pts each) Name the following compounds.
   a. SiO\textsubscript{2} ________________________________
   b. Fe(\text{ClO})\textsubscript{3} ________________________________

10. (3 pts each) Write the formula for each of the following compounds.
    a. Barium permanganate ________________________________
    b. Copper (I) sulfite ________________________________

11. (6 pts) Label the following binary compounds as ionic, polar covalent, or purely covalent. Then explain your reasoning.
    NO ___________ LiI ___________ N\textsubscript{2} ___________

12. (6 pts each) Draw Lewis structures, including any resonance forms, for:
    NO\textsubscript{3}\textsuperscript{-1} XeF\textsubscript{4
}
13. (1 pt each) Fill in the blanks for each structure

<table>
<thead>
<tr>
<th>Molecular Shape</th>
<th>Polar (yes/no)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{BrF}_3 )</td>
<td>________________</td>
</tr>
<tr>
<td>( \text{TeOF}_2 )</td>
<td>________________</td>
</tr>
<tr>
<td>( \text{UF}_3 )</td>
<td>________________</td>
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14. (6 pts) The electron configuration for \( {}^{34}\text{Se} \) is \([\text{Ar}]\ 4s^2\ 3d^{10}\ 4p^4\). Is \( +1 \) expected to be a stable charge for Se? Explain your reasoning.

15. (6 pts) Write the electron configuration for \( {}^{42}\text{Mo} \). You may start with an inert gas core if you wish.

16. Using a procedure similar to the one you did in lab, the \( \text{CaCO}_3 \) content of limestone can be determined by titrating it with HCl. The titration reaction is:

\[
\text{CaCO}_3 + \text{HCl} \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{CaCl}_2
\]

a. (6 pts) Balance the reaction.

b. (10 pts) If titration of one sample of limestone took 19.37 mL of 0.1500 M HCl, how many moles of \( \text{CaCO}_3 \) were there in the sample?

17. (6 pts) Which is larger \( \text{Cl}^+ \) or \( \text{Cl}^- \)? Explain your reasoning.

18. (6 pts) What is the formal charge on oxygen in the Lewis structure shown? Show your work.

19. (6 pts) You have come to lab a bit early and are visiting with your classmates before lab begins. No one is working in the lab. Why is it still hazardous to eat something like a granola bar or drink a bottle of pop in the lab while you wait?

Chemistry 120

Exam 3

April 13, 2005

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<th>AX₆</th>
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<td>see saw</td>
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<td>bent</td>
<td>AX₃E₂³</td>
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<td>AX₂E₂</td>
<td>AX₃E₃</td>
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<td>trigonal pyramid</td>
<td>AX₂E₂</td>
<td>AX₃E₂</td>
</tr>
<tr>
<td>AX₇</td>
<td>bent</td>
<td>AX₃E₂</td>
<td>linear</td>
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Circle the correct answer:

1. (3 pts) What is the oxidation number of the oxygen atom in H₂O₂?
   a) +1  b) +2  c) -2  d) -1

2. (3 pts) What is the molar concentration of sodium ions in a 0.150 M Na₂SO₄ solution?
   a) 0.0750 M  b) 0.150 M  c) 0.300 M  d) 0.450 M

3. (3 pts) Which pair of compounds is soluble in water?
   a) KI and Ba(NO₃)₂  b) AgBr and AgI  c) CdS and (NH₄)₂S  d) NaNO₃ and CuCO₃

4. (3 pts) When K₂SO₄ (aq) and Pb(NO₃)₂ (aq) are mixed, a white colored precipitate forms which is
   a) K₂SO₃  b) KNO₃  c) Pb  d) PbSO₄

5. (3 pts) The reaction of HNO₃ (aq) + KOH (aq) \( \rightarrow \) KNO₃ (aq) + H₂O (l) is best classified as a(n)
   a) single replacement reaction  b) precipitation reaction  c) oxidation-reduction reaction  d) acid-base reaction

6. (3 pts) The reaction of Pb(NO₃)₂ (aq) + K₂SO₄ (aq) \( \rightarrow \) PbSO₄ (s) + 2 KNO₃ (aq) is best classified as a(n)
   a) single replacement reaction  b) precipitation reaction  c) oxidation-reduction reaction  d) acid-base reaction
7. (3 pts) Predict the products of a reaction between Zn(NO₃)₂ (aq) and K₂CO₃ (aq).

a) ZnCO₃ (aq) and KNO₃ (aq)  b) Zn(NO₃)₂ (aq) and K₂CO₃ (aq)

8. (3 pts) Acetic acid (CH₃CO₂H), formic acid (HCO₂H), hydrofluoric acid (HF), and ammonia (NH₃) are commonly classified as

a) acids             b) bases     c) weak electrolytes         d) strong electrolytes

9. (3 pts) The net ionic equation for the neutralization reaction of HCN (aq) with NaOH (aq) is

a) HCN (aq) + NaOH (aq) → NaCN (aq) + H₂O (l)

10. (3 pts) Three different substances, A₂X, A₂Y, and A₂Z, were dissolved in water with the following results. (Water molecules are omitted for clarity.) Which of the substances is the strongest electrolyte, and which is the weakest?

a) A₂X is the strongest electrolyte and A₂Y is the weakest electrolyte.

11. (6 pts) Circle the compounds that will be strong bases in water (may be more than one).

Sr(OH)₂, Na₂O, HClO₂, NH₃, Al(OH)₃, none

12. (3 pts each) Name the following compounds.

a. H₂S  b. NiBr₂•6H₂O

13. (3 pts each) Write the formula for each of the following compounds.

a. nitrous acid  b. lead (IV) perchlorate

14. (2 pts each) Predict the products of the following reactions (you do not need to balance the reaction).

a. K + I₂ →

b. H₂SO₄ + Al(OH)₃ →

15. (10 pts) Balance the following redox reaction which takes place in an acidic, aqueous solution:

\[ \text{NO}_3^- (aq) + \text{Mg} (s) \rightarrow \text{NO} (g) + \text{Mg}^{2+} (aq) \]

16. (6 pts) When Mg(ClO₄)₂ is dissolved in water, will the resulting solution be acidic, basic, or neutral? Explain your reasoning, showing reactions where appropriate.

17. (10 pts) Write and balance the net ionic reaction. It is not a redox reaction.

\[ \text{HI} + \text{Zn(C}_2\text{H}_5\text{O}_2\text{)}_2 \rightarrow \text{ZnI}_2 + \text{HC}_2\text{H}_3\text{O}_2 \]
18. While in lab, your lab partner accidentally slops 10 mL of 1 M HCl onto your bare arm.
   a. (3 pts) What action should you take?
   b. (3 pts) What action should your lab partner take?

19. (6 pts) Draw the Lewis structure for H₂SO₄ including any resonance structures.

20. (10 pts) Ammonia is produced commercially by the Haber process:
    \[3 \text{H}_2 (g) + \text{N}_2 (g) \rightarrow 2 \text{NH}_3 (g)\]
    The yield from this reaction is highly dependent on the reaction temperature, and this reaction has to have at least a 90.0% yield to be turn a profit for the company. In one test run at 400°C, when 3.784 moles of hydrogen was mixed with an excess of nitrogen, 2.384 moles of ammonia was actually produced. Will it be profitable for the company to run the reaction at this temperature? Show your work and/or explain your reasoning.
### Enthalpies of Formation ($\Delta H_f$) for Selected Species

<table>
<thead>
<tr>
<th>Species</th>
<th>$\Delta H_f$ (kJ/mole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C$<em>{10}$H$</em>{22}$ (l)</td>
<td>-59.67</td>
</tr>
<tr>
<td>CH$_3$OH (l)</td>
<td>-238.7</td>
</tr>
<tr>
<td>C$_2$H$_5$OH (l)</td>
<td>-277.7</td>
</tr>
<tr>
<td>CO (g)</td>
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<tr>
<td>CO$_2$ (aq)</td>
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<tr>
<td>CO$_2$ (g)</td>
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</tr>
<tr>
<td>H$_2$O (g)</td>
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<tr>
<td>H$_2$O (l)</td>
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<tr>
<td>O (g)</td>
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<td>O$_2$ (g)</td>
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</tr>
<tr>
<td>O$_3$ (g)</td>
<td>+143</td>
</tr>
</tbody>
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1. (3 pts each) Name the following compounds.
   a. Fe(ClO$_4$)$_3$ ________________________________
   b. HNO$_2$ ________________________________

2. (3 pts each) Write the formula for each of the following compounds.
   a. Ammonium nitrate ________________________________
   b. Phosphorous acid ________________________________

3. (3 pts) A basketball is inflated to a pressure of 1.50 atm in a 20.0°C garage. What is the pressure of the basketball outside where the temperature is 10.0°C?
   A) 0.750 atm  B) 1.55 atm  C) 1.45 atm  D) 3.00 atm

4. (3 pts) Molecules of a liquid can pass into the vapor phase only if the
   A) liquid has little surface tension.
   B) vapor pressure of the liquid is high.
   C) temperature of the liquid is near its boiling point.
   D) molecules have sufficient kinetic energy to overcome the intermolecular forces in the liquid.

5. (3 pts) Which is expected to have the largest dispersion forces?
   A) CH$_4$  B) CS$_2$  C) O$_2$  D) C$_{10}$H$_{22}$

6. (3 pts) Which compound exhibits the strongest intermolecular interactions?
   A) SO$_3$  B) CaF$_2$  C) O=Si(OH)$_2$  D) B & C

7. (3 pts) Which of the following compounds can exhibit hydrogen bonding between its molecules?
   A) CH$_3$CH$_2$CH$_3$  B) H$_3$C-O-CH$_3$  C) CH$_3$CH$_2$OH  D) O=C(CH$_3$)$_2$

8. (3 pts) Which box represents the system with the highest entropy?
   A) box (a)  B) box (b)  C) box (c)  D) box (d)
9. (3 pts) The first law of thermodynamics

A) defines chemical energy.  B) is a statement of conservation of energy.
C) defines entropy.  D) provides a criterion for the spontaneity of a reaction.

10. (3 pts) What is the equilibrium constant expression \( K_{eq} \) for:
\[
\text{Fe}_2(\text{CO}_3)_3 (s) + 6 \text{HNO}_3 (aq) \rightleftharpoons 2 \text{Fe(NO}_3)_3 (aq) + 3\text{H}_2\text{O (l)} + 3 \text{CO}_2 (g)
\]
A) \( K_{eq} = \frac{[\text{Fe(NO}_3)_3]^2[\text{H}_2\text{O}]^3[\text{CO}_2]^3}{[\text{Fe}_2(\text{CO}_3)_3][\text{HNO}_3]^6} \)
B) \( K_{eq} = \frac{[\text{Fe(NO}_3)_3]^2[\text{H}_2\text{O}]^3[\text{CO}_2]^3}{[\text{Fe}_2(\text{CO}_3)_3][\text{HNO}_3]^6} \)
C) \( K_{eq} = \frac{[\text{Fe(NO}_3)_3]^2[\text{CO}_2]^3}{[\text{Fe}_2(\text{CO}_3)_3][\text{HNO}_3]^6} \)
D) \( K_{eq} = \frac{[\text{Fe(NO}_3)_3]^2[\text{CO}_2]^3}{[\text{HNO}_3]^6} \)

11. (3 pts) The following pictures represent equal volumes of aqueous solutions of three acids HA (A = X, Y, or Z); water molecules have been omitted for clarity. Arrange the acids in order of increasing acid strength.

A) HZ < HY < HX  B) HZ < HX < HY  C) HX < HZ < HY  D) HY < HZ < HX

12. (3 pts) The vapor pressure of a pure liquid increases as the

A) intermolecular attractive forces increase.
B) average kinetic energy of the molecules in the liquid phase decreases.
C) temperature of the liquid phase increases.
D) temperature of the liquid phase decreases.

13. (3 pts) The decomposition of nitrosyl bromide is exothermic: 2 NOBr(g) \( \rightarrow \) 2 NO(g) + Br\(_2\)(g). Which of the following changes in reaction condition will result in production of more reactants?
A) add more NO  B) decrease the temperature  C) add more NOBr  D) none of the above

14. (3 pts) The \( \Delta S \) for a precipitation reaction is generally negative. For these reactions to be spontaneous, the reaction must be
A) endothermic  B) exothermic  C) also an acid-base reaction  D) none of the above

15. (8 pts) When CaCl\(_2\) is dissolved in water, will the solution be acidic, basic, or neutral? Explain your reasoning, showing reactions where appropriate.
16. (7 pts) Using the enthalpies of formation on the first page of the exam, calculate the $\Delta H^\circ$ for the reaction:

$$2 \text{ CO (g)} + \text{ O}_2 (g) \rightarrow 2 \text{ CO}_2 (g)$$

17. (7 pts) When 0.525 mole NH$_3$(g) reacts in an excess of O$_2$(g) according to the following chemical equation, the reaction absorbs 153.3 J of energy from the surroundings. What is the $\Delta H^\circ$ for the reaction?

$$4 \text{ NH}_3(g) + 5 \text{ O}_2(g) \rightarrow 4 \text{ NO}(g) + 6 \text{ H}_2\text{O}(l)$$

18. (8 pts) How many molecules of N$_2$ are in a 500.0 mL container at 780 mm Hg and 135°C?

19. (7 pts) What is the pH of 5 x 10$^{-5}$ M Sr(OH)$_2$?

20. (8 pts) Is PCl$_3$ or PCl$_5$ more soluble in liquid CHBr$_3$? Explain your reasoning.

21. (7 pts) Why are sandals not acceptable footwear in a chemistry lab?