1. (3 pts) If SbO$_3^-$ is called stibnite, what is the formula for perstibnate? Explain your reasoning.

2. (2 pts) Write the formula of the compound that results when UO$_2^{+2}$ combines with AsO$_4^{-3}$

3. (2 pts each) Name the following compounds.
   a. NO$_2$  

   b. Co$_3$N$_2$  

   c. Sn(C$_2$H$_3$O$_2$)$_2$  

4. (2 pts each) Write the formula for each of the following compounds.
   a. sulfur trioxide  

   b. zinc fluoride  

   c. manganese (III) sulfate
5. (2 pts) How many decimal places should there be in measurements made with the ruler shown below?

![Ruler Image]

6. (1 pt each) Give an example for each of the following:

   transition metal __________________________
   gaseous element (at room temperature) __________________________
   halogen __________________________
   element where the electrons farthest from the nucleus are in the 5th shell __________________________
   element with a principle charge of +5 __________________________

7. (2 pts) What is the oxidation number (charge) on Mn in Ca(MnO₄)₂? Explain your reasoning.

8. (1 pt each) How many protons, electrons, and neutrons are there in the tellurium ion shown below?

   \[
   \text{Te}^{-3} \quad \frac{128}{52} \quad \text{#p} \quad \text{#n} \quad \text{#e}
   \]

9. (7 pts) A hot topic in the science arena these days is carbon nanotubes; carbon atoms arrange to form small tubes with dimensions in the nanometer range. Carbon nanotubes from one preparation were found to be 12.3 nm long. What is this length expressed in centimeters?

10. (8 pts) How many grams of Zn(NO₃)₂ must be dissolved in 145 mL to make a 0.015 M solution?

11. Combustion of propane follows the same type of reaction as burning methane which you studied in lab. The reaction is:

   \[
   \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}
   \]

   a. (5 pts) Balance the reaction.

   b. (8 pts) If 0.66 g of C₃H₈ is mixed with 1.44 g of O₂ and burned, which reactant will be the limiting reagent? Explain your reasoning.
12. (8 pts) What is the mass in grams of exactly 5 molecules of SO$_2$?

13. (6 pts) Why is it NOT a good idea to store coats and bookbags on the lab benches in lab?

14. (8 pts) Which atom has the larger radius: Al or P? Explain your reasoning.

15. A x-ray (light) emitted from an excited atom has a frequency of $3.817 \times 10^{18}$ Hz.
   a. (4 pts) What is the wavelength of that radiation in nanometers?
   b. (4 pts) What is the energy of one photon of that light?

16. The industrial process for making anhydrous ammonia uses the Haber Process. The balanced reaction is:

   $$3 \text{H}_2 + \text{N}_2 \rightarrow 2 \text{NH}_3$$

   a. (8 pts) The extent of reaction (yield) depends on the operating conditions. In one batch 5.31 kmole of hydrogen was mixed with an excess of nitrogen. What is the expected yield from this batch if all the hydrogen is converted to ammonia (theoretical yield)?

   b. (5 pts) If 2.524 kmole of ammonia was actually recovered from this reaction, what is the percent yield for the reaction?

---

Chemistry 120

Exam 2

Name __________________

March 17, 2004

CONSTANTS AND EQUATIONS YOU MAY NEED

<table>
<thead>
<tr>
<th>$N_o$</th>
<th>$6.022 \times 10^{23}$ particle/mole</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1 \text{mL}$</td>
<td>$1 \text{cm}^3$</td>
</tr>
<tr>
<td>$c$</td>
<td>$\lambda \nu$</td>
</tr>
<tr>
<td>$E$</td>
<td>$h \nu$</td>
</tr>
<tr>
<td>$c$</td>
<td>$2.998 \times 10^8 \text{m/s}$</td>
</tr>
<tr>
<td>$h$</td>
<td>$6.626 \times 10^{-34} \text{J@photon}$</td>
</tr>
</tbody>
</table>

---

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)

---

<table>
<thead>
<tr>
<th>IONS</th>
<th>Soluble/Insoluble</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I metals and NH$_4^+$</td>
<td>soluble</td>
<td>none</td>
</tr>
<tr>
<td>Nitrates, Acetates, Perchlorates</td>
<td>soluble</td>
<td>none</td>
</tr>
<tr>
<td>Fluoride</td>
<td>soluble</td>
<td>Group II</td>
</tr>
</tbody>
</table>
IONS | Soluble/Insoluble | Exceptions
---|---|---
Chlorides, Bromides, and Iodides | soluble | silver, lead, mercury(I)
Sulfates | soluble | strontium, barium, lead
Other anions | insoluble | Group I, ammonium, Group II sulfides, barium oxide & hydroxide, strontium oxide & hydroxide

| $AX_2$ | linear | $AX_2$ | trigonal bipyramid | $AX_6$ | octahedral |
| $AX_3$ | trigonal planar | $AX_4E$ | see saw | $AX_4E$ | square pyramid |
| $AX_4$ | bent | $AX_4E_2$ | T | $AX_4E_2$ | square planar |
| $AX_5$ | tetrahedral | $AX_5E_3$ | linear | $AX_5E_3$ | T |
| $AX_5E_2$ | trigonal pyramid | $AX_5E_4$ | linear |
| $AX_6E_2$ | bent | |

**SHOW YOUR WORK. NO WORK, NO CREDIT**

**INCLUDE LABELS AND PROPER NUMBER OF SIG FIGS**

Up to 75% of the credit for a problem will be given for correctly setting it up, including labels on all numbers.

1. (3 pts each) Name the following compounds.
   
a. AgCN ________________________________
   
b. Cu$_3$PO$_2$ ________________________________
   
c. Cl$_2$O$_7$ ________________________________

2. (3 pts each) Write the formula for each of the following compounds.
   
a. magnesium nitride ________________________________
   
b. iron (II) perbromate ________________________________
   
c. ammonium sulfite ________________________________

3. (6 pts) Label the following binary compounds as ionic, polar covalent, or purely covalent. Then explain your reasoning.
   
   CIF  ___________    NaCl  ___________    Cl$_2$  ___________

4. (6 pts) The electron configuration for $^{43}$Tc is [Kr] 5s$^2$ 4d$^4$. Is +4 expected to be a stable charge for Tc? Explain your reasoning.

5. (7 pts) Green light from a mercury vapor lamp has a wavelength of 550 nm. What is the energy
of one photon of that green light?

6. (6 pts) Write the electron configuration for $^{206}$Po. You may start with an inert gas core if you wish.

7. Which is the largest in each set? Explain your reasoning.
   a. (3 pts) Cl, Ar, K
   b. (3 pts) Cl$^{-1}$, Ar$^{0}$, K$^{+1}$

8. (4 pts) What is the formal charge on nitrogen in the Lewis structure shown below? Show your work.

\[
\left[ :\ddot{O}=C=\ddot{N} : \right]^{-1}
\]

9. (5 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 XeF$_4$, a reasonably stable compound (Lewis structure similar to XeF$_2$Cl$_2$ shown above). 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.

10. (6 pts) Is the following reaction which takes place in aqueous solution a precipitation reaction? Explain your reasoning.

\[
2 \text{NaCl} + \text{SnSO}_4 \rightarrow \text{SnCl}_2 + \text{Na}_2\text{SO}_4
\]

11. (5 pts each) Draw Lewis structures, including any resonance forms, for:

\[
\text{CO}_3^{2-}, \quad \text{PCl}_3
\]
12. (8 pts) Fill in the blanks for each structure

<table>
<thead>
<tr>
<th>Molecular Shape</th>
<th>Molecular Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–O–H</td>
<td>H–N–H</td>
</tr>
<tr>
<td>Polar (yes/no)?</td>
<td>Polar (yes/no)?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Molecular Shape</th>
<th>Molecular Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>O=C=S</td>
<td>U–F–F</td>
</tr>
<tr>
<td>Polar (yes/no)?</td>
<td>Polar (yes/no)?</td>
</tr>
</tbody>
</table>

13. Using a procedure just like the one you did in lab last week, phosphoric acid, H₃PO₄, was titrated with NaOH. The titration reaction is:

\[ \text{NaOH} + \text{H}_3\text{PO}_4 \rightarrow \text{H}_2\text{O} + \text{Na}_2\text{HPO}_4 \]

a. (5 pts) Balance the reaction.

b. (7 pts) If titration of one sample of H₃PO₄ took 26.83 mL of 0.1500 M NaOH, how many grams of H₃PO₄ were there in the sample?

14. 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?
SHOW YOUR WORK. NO WORK, NO CREDIT

INCLUDE LABELS AND PROPER NUMBER OF SIG FIGS

Up to 75% of the credit for a problem will be given for correctly setting it up, including labels on all numbers.

CONSTANTS AND EQUATIONS YOU MAY NEED

N<sub>a</sub> = 6.022 x 10<sup>23</sup> particle/mole

1 mL = 1 cm<sup>3</sup> 1 atm = 760 torr = 14.7 lb/in<sup>2</sup> 101.325 kPa 1 torr = 1 mm Hg

R = 0.08206 L atm/K mole

62.36 L/cm<sup>3</sup> 62360 mL/atm K = C%273.16

PV = nRT

P<sub>T</sub> = P<sub>1</sub>%P<sub>2</sub>%P<sub>3</sub>%...

D = m/V

c = hν

E = hv

c = 2.998 x 10<sup>8</sup> m/s

h = 6.626 x 10<sup>-34</sup> J/s photon

C<sub>p</sub>(H<sub>2</sub>O) = 4.184 J/g deg

q<sub>lost</sub> = q<sub>gained</sub>

q = mC<sub>p</sub>∆T

ΔH = q/mole lim reagent

ΔG = ΔH + TΔS

IONS

Soluble/Insoluble

Exceptions

Group I metals and NH<sub>4</sub><sup>+</sup> soluble none
Nitrates, Acetates, Perchlorates soluble none
Fluoride soluble Group II
Chlorides, Bromides, and Iodides soluble silver, lead, mercury(I)
Sulfates soluble strontium, barium, lead
Other anions insoluble Group I, ammonium, Group II sulfides, barium oxide & hydroxide, strontium oxide & hydroxide

AX<sub>2</sub> linear AX<sub>3</sub> trigonal bipyramid AX<sub>4</sub> tetrahedral AX<sub>5</sub> trigonal planar

AX<sub>5</sub>E linear AX<sub>4</sub>E linear AX<sub>3</sub>E<sub>2</sub> linear AX<sub>2</sub>E<sub>2</sub> bent

AX<sub>2</sub>E<sub>2</sub>bent AX<sub>3</sub>E<sub>2</sub>bent AX<sub>4</sub>E<sub>2</sub>bent AX<sub>2</sub>E<sub>2</sub>bent

Enthalpies of Formation (∆H<sub>f</sub>) for Selected Species

C<sub>10</sub>H<sub>22</sub>(l) -59.67 kJ/mole H<sub>2</sub>O -241.8 kJ/mole

H<sub>2</sub>O (g)

CH<sub>3</sub>OH (l) -238.7 kJ/mole H<sub>2</sub>O (l) -285.8 kJ/mole

O (g) +249.2 kJ/mole

CO (g) -110.5 kJ/mole O<sub>2</sub> (g) 0 kJ/mole

O<sub>2</sub> (g) +143 kJ/mole

CO<sub>2</sub> (aq) -413.8 kJ/mole O<sub>3</sub> (g) +143 kJ/mole

CO<sub>2</sub> (g) -393.5 kJ/mole

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)
1. (2 pts each) Name the following compounds.
   a. HClO₄ ________________________________
   b. (NH₄)₂CO₃ ________________________________

2. (2 pts each) Write the formula for each of the following compounds.
   a. hydrosulfuric acid ________________________________
   b. Chlorine (VII) sulfide ________________________________

3. (5 pts) Circle the compounds that will be strong bases in water:

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

4. (11 pts) One way of obtaining iron from its oxide ores in the laboratory is to react the ore with carbon monoxide:

   Fe₂O₃ (s) + 3 CO (g) ! 2 Fe (s) + 3 CO₂ (g)

   If the reaction of 0.4385 mole of Fe₂O₃ with an excess of CO generated 11 kJ of heat, what is the ΔH for this reaction?

5. (7 pts) Why are sandals not acceptable footwear in a chemistry lab?

6. (8 pts) Ammonia is produced commercially by the Haber process:

   3 H₂ (g) + N₂ (g) ! 2 NH₃ (g)

   The ΔH for the reaction is -92.2 kJ and the ΔS is -198.7 J/K. At what temperature will the ΔG (free energy) equal zero?

7. (8 pts) When K₂SO₃ is dissolved in water, will the resulting solution be acidic, basic, or neutral? Explain your reasoning, showing reactions where appropriate.

8. (10 pts) Write and balance the net ionic reaction. It is not a redox reaction.

   H₂SO₄ + BaI₂ ! BaSO₄ + HI
9. (8 pts) One aspect of photosynthesis can be summarized as the reaction of carbon dioxide with water to form glucose:

\[ 6 \text{CO}_2 (g) + 6 \text{H}_2\text{O} (l) \rightarrow C_6\text{H}_{12}\text{O}_6 (aq) + 6 \text{O}_2 (g) \]

Using the table of enthalpies of formation (\(\Delta H_f\)'s) on the front page and the fact that the \(\Delta H\) for the above reaction is +2820 kJ, what is the enthalpy of formation for glucose?

10. (4 pts) What are the two characteristics of an ideal gas discussed in class?

11. (10 pts) Balance this oxidation-reduction reaction which occurs in acid solution.

\[ \text{Cu} + \text{NO}_3^{-1} \rightarrow \text{Cu}^{2+} + \text{NO}_2 \]

12. (10 pts) Consider the reaction: \(\text{Ba(OH)}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2 \text{H}_2\text{O}\)

a. Is this a precipitation reaction? Explain how you decided.

b. Is this an acid-base reaction? Explain how you decided.

c. Is this an oxidation-reduction reaction? Explain how you decided.

13. (11 pts) Limestone reacts with nitric acid:

\[ \text{CaCO}_3 (s) + 2 \text{HNO}_3 (aq) \rightarrow \text{Ca(NO}_3)_2 (aq) + \text{H}_2\text{O} (l) + \text{CO}_2 (g) \]

If 0.2000 mole of HNO₃ was reacted with excess CaCO₃ at 25°C and 0.943 atm, what volume of CO₂ was collected?
SHOW YOUR WORK. NO WORK, NO CREDIT

INCLUDE LABELS AND PROPER NUMBER OF SIG FIGS

Up to 75% of the credit for a problem will be given for correctly setting it up, including labels on all numbers.

CONSTANTS AND EQUATIONS YOU MAY NEED

\[ N_0 = 6.022 \times 10^{23} \text{ particle/mole} \]
\[ 1 \text{ mL} = 1 \text{ cm}^3 \]
\[ D = \frac{m}{V} \]
\[ c = \lambda \nu \]
\[ E = h \nu \]
\[ c = 2.998 \times 10^8 \text{ m/s} \]
\[ h = 6.626 \times 10^{-34} \text{ J@s} \]
\[ C_p(H_2O) = 4.184 \frac{\text{J@g}}{\text{deg}} \]
\[ q_{\text{lost}} = q_{\text{gained}} = q = mC_p\Delta T \]
\[ \Delta H = \frac{q}{\text{mole}} \]
\[ \Delta G = \Delta H + T\Delta S \]
\[ K = \frac{C}{R} \]
\[ nRT = P \]
\[ PV = nRT \]
\[ P = \frac{RT}{V} \]
\[ \ln n = \ln [A]_0 - \ln [A]_t \]
\[ k = A e^{-\frac{E_a}{RT}} \]
\[ \Delta H_f = \text{enthalpies of formation} \]

IONS

<table>
<thead>
<tr>
<th>Group I metals and NH$_4^+$</th>
<th>Soluble/Insoluble</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrates, Acetates, Perchlorates</td>
<td>soluble</td>
<td>none</td>
</tr>
<tr>
<td>Fluoride</td>
<td>soluble</td>
<td>Group II</td>
</tr>
<tr>
<td>Chlorides, Bromides, and Iodides</td>
<td>soluble</td>
<td>silver, lead, mercury(I)</td>
</tr>
<tr>
<td>Sulfates</td>
<td>soluble</td>
<td>strontium, barium, lead</td>
</tr>
<tr>
<td>Other anions</td>
<td>insoluble</td>
<td>Group I, ammonium, Group II sulfides, barium oxide &amp; hydroxide, strontium oxide &amp; hydroxide</td>
</tr>
</tbody>
</table>

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 kJ/mole</td>
</tr>
<tr>
<td>H$_2$O (g)</td>
<td>-241.8 kJ/mole</td>
</tr>
<tr>
<td>CH$_4$OH (l)</td>
<td>-238.7 kJ/mole</td>
</tr>
<tr>
<td>C$_2$H$_5$OH (l)</td>
<td>-277.7 kJ/mole</td>
</tr>
<tr>
<td>CO (g)</td>
<td>-110.5 kJ/mole</td>
</tr>
<tr>
<td>CO$_2$ (aq)</td>
<td>-413.8 kJ/mole</td>
</tr>
<tr>
<td>CO$_2$ (g)</td>
<td>-393.5 kJ/mole</td>
</tr>
</tbody>
</table>

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)
1. (3 pts each) Name the following compounds.
   a. HgSO₄ ________________________________
   b. HBrO₄ ________________________________

2. (3 pts each) Write the formula for each of the following compounds.
   a. lead (IV) phosphate ________________________________
   b. hypochlorous acid ________________________________

3. (6 pts) Which of the following molecules would exhibit dipole-dipole interactions: CO₂, MgO, NCl₃? Explain why one does and the other two do not.

4. (6 pts) Write the equilibrium constant expression for:

   \[ \text{Ba(HSO}_3\text{)}_2 (s) + 2 \text{NaOH (aq)} \rightarrow \text{BaSO}_3 (s) + \text{Na}_2\text{SO}_3 (aq) + 2 \text{H}_2\text{O (l)} \]

   \[ K_{eq} = \]

5. (6 pts) Which of the following two solutions is a buffer? Explain your reasoning.
   0.5 M HNO₃  +  0.3 M NaNO₃  
   0.5 M HNO₂  +  0.3 M NaNO₂

6. (10 pts) In an experiment similar to the one you did in the gas law lab, a student dissolved a metal in concentrated hydrochloric acid and collected the hydrogen gas that formed. This metal reacted with HCl according to the following net ionic reaction:

   \[ 2 \text{M (s)} + 6 \text{H}^{+} \rightarrow 2 \text{M}^{3+} + 3 \text{H}_2 \]

   After reacting 0.4935 g of metal with an excess of HCl, the student had collected 693.4 mL of hydrogen gas at 20.0°C. The partial pressure of the hydrogen in the collection flask was 719.3 torr. What is the molar mass of the metal.

7. (7 pts) The gases NO₂ and SO₃ are blamed for causing acid rain. But neither of these molecules has any hydrogen. How can they make rain acidic? Include appropriate reactions in your explanation.

8. (7 pts) Sulfur and oxygen are in the same group, so H₂O and H₂S will have the same shape and both are polar molecules. Since stickiness of molecules is expected to increase as the molar mass increases (bigger molecules exhibit greater dispersion force contribution to stickiness), H₂S molecules should be stickier than H₂O molecules. However, at room temperature H₂O is a liquid and H₂S is a gas; the opposite of what is expected. Explain why H₂O is stickier than H₂S.

9. (10 pts) Is SiCl₃F or SiCl₄ expected to be more soluble in CBr₄? Include appropriate Lewis structures in your explanation of your reasoning.

10. (10 pts) What is the pH of a 5.00 x 10⁻⁴ M H₂SO₄ solution?
11. (7 pts) When (NH₄)₂SO₄ is dissolved in water, will the resulting solution be acidic, basic, or neutral? Write reactions to show your reasoning.

12. (5 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. (3 pts) What is the conjugate acid of SO₃²⁻?

14. (5 pts) Insoluble salts in water form an equilibrium with its ions. For example:

   \[ \text{Zn(ClO}_2\text{)}_2 (s) \rightleftharpoons \text{Zn}^{2+} (aq) + 2 \text{ClO}_2^- (aq) \]

If concentrated HCl is added to a solution containing the equilibrium shown, will the amount of zinc chlorite solid increase, decrease (dissolve), or stay the same? Assume the volume of HCl added is negligible. Explain your reasoning.

15. (10 pts) What is the pH of 0.0135 M acetic acid (Kₐ = 1.8 x 10⁻⁵)?